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## Specific problem solution and distant learning

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## Specific problem solution and distant learning

### Abstract

This document is an overview of a project to identify the cause of a coolant overheating complaint on a diesel engine that powers a mechanical lift machine, implement a short-term solution and place into action a long-term solution. The short-term correction was to make necessary repairs in the field, long-term solution includes distant training of the mechanical lift machine assembly line and training on the proper assembly procedure of assembling the alternator pulley to the alternator shaft.

The project utilized problem evaluation (Root Cause Analysis), implementing corrective action (short term and long term), and training through distant communication via Internet and digital files. This paper will provide a brief overview of the project, steps to determine the corrective action, media to communicate via the Internet and the training of the mechanical lift assembly line individuals through distant learning.

SPECIFIC PROBLEM SOLUTION AND DISTANT LEARNING

A Graduate Project Paper

Submitted to the

Division of Educational Technology

Department of Curriculum and Instruction

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Master of Arts

by

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## ABSTRACT

This document is an overview of a project to identify the cause of a coolant overheating complaint on a diesel engine that powers a mechanical lift machine, implement a short-term solution and place into action a long-term solution. The short-term correction was to make necessary repairs in the field, long-term solution includes distant training of the mechanical lift machine assembly line and training on the proper assembly procedure of assembling the alternator pulley to the alternator shaft. The project utilized problem evaluation (Root Cause Analysis), implementing corrective action (short term and long term), and training through distant communication via Internet and digital files. This paper will provide a brief overview of the project, steps to determine the corrective action, media to communicate via the Internet and the training of the mechanical lift assembly line individuals through distant learning.

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## Introduction

Purpose of this project paper is to outline steps taken to search for cause and corrective steps. Individuals involved in this project searched for variables, exchanged materials on-line, extracted feedback, provided steps for corrective action and training for assembly line personnel. The project members developed communication that encouraged and supported an active interaction between all parties. This author searched for a correction conducive to a satisfactory conclusion for every individual.

A form of distant learning/communication was applied within this project. Robert Hardman (personal communication, October 3, 1997) stated, "distance education simply means the instructor and student are separated by space and time." This project clearly supported Dr. Hardman's statement as information was passed from Ohio, Iowa, Illinois, Kentucky, United Kingdom and Mexico over a time frame of nine months.

The project begins with a businessman who is delayed by a piece of malfunctioning equipment. The owner of the machinery had to slow down production and operate at 50% of his mechanical lift's capability. If the operator did not slow the engine's temperature gauge would swing into the red zone, potentially causing damage to several components of the mechanical lift's engine. The businessman's challenge was that his

production followed the performance of the mechanical lift. Production output and prompt service to his customers began to slow as a result of the mechanical lift's malfunction. The businessman's customers did not like or want delayed shipments of the products and voiced their complaints to the owner.

Background of the problem started with a Mechanical Lift machine, which the engine's cooling system overheated due to the fan belt becoming dislodged from the drive pulleys. This machine required fan belt repairs sporadically, once at 500 hours of operation (once within the first hour after production). To further the challenge among the elements associated with this problem were constraints such as distance between each of the parties involved, occurrence of failure and determining the true cause for these failures. Spitzer (1998) noted, "a compelling economic case can be made that distance education is more cost-effective than conventional instruction" (p.45). General resources such as technical manuals or experts' advice, an in-person investigation, and follow-up were not conducive to this project when you factor in the convenience and associated costs.

Early in the project a conference call was held to determine a common ground for communications. The tele-conference was over the telephone with speakerphones and involved seven individuals. During the conversion a common platform for communication, besides the use of



the telephone, was discussed. A key factor of the project's success would be focused on the human aspects of distant learning (Spitzer, 1998), utilizing the technology resources that team members are familiar with and willing to use. The group consensus agreed conference calls, voicemail messages, and email would be common grounds for communications. Team members agreed that email would allow communications any time of the day and be flexible enough to fit into everyone's busy schedules. Keegan (1996) states, "electronic communications (email) provided learning when members are separated by time, space and various levels of technology" (p.45).

The maintenance supervisor inspected the mechanical lift equipment to determine the cause of the productivity loss. His inspection was to find the cause of the delays and repair the problem quickly. Reviewing the maintenance records of the Mechanical Lift machine showed it to be within the machine's warranty period. Quickly, the maintenance supervisor contacted his mechanical lift dealer and requested assistance in correcting the cause for the diesel engine overheating in the mechanical lift. A repair technician was dispatched to the site of the overheating piece of equipment. After a quick inspection of the machine the technician observed that the fan belt was missing. A fan drive belt was installed and properly tensioned. Upon completion, the technician was sure he had corrected the problem. He informed the

owner of the corrections he had performed and returned to the mechanical lift dealership.

Within two weeks after the repair the mechanical lift operator noticed that the diesel engine's temperature gauge was in the red zone (operating hot again). It did not take the operator long to report the cooling problem to his maintenance supervisor who in turn quickly determined that the equipment repairperson did not repair the mechanical lift correctly. A telephone call was placed to bring the repair technician back to the business site for a second attempt to correct the overheating complaint. Again the repair technician observed that the fan belt was the problem. Repairs were repeated as on the previous repair (the replacement of the fan drive belt) however after the installation of the fan belt was completed, the technician started the engine and watched the fan belt. The technician made a mental note, observing that the fan belt did not track true within the fan belt drive pulleys. This observation led the technician to check for fan belt drive and associated pulley alignment. Upon the completion of the alignment check the alternator pulley was identified as being out of alignment. Again the technician completed the necessary repairs to the Mechanical Lift machine. The technician informed the maintenance supervisor that this time the re-alignment of the alternator and replacement of the fan belt would correct the overheating complaint.

When the service technician had returned to the mechanical lift dealership he notified his supervisor of the steps necessary to correct the problem causing the mechanical lift to overheat. Alignment of the alternator to the other pulleys in the fan belt drive caused the fan belt to jump off of the alternator pulley and the fan stop turning. He indicated that the customer was currently pleased with the performance of mechanical lift machine after the alternator was correctly re-aligned and a new fan belt installed. A warranty claim for parts and labor of the two repairs was submitted to the manufacturer of the mechanical lift. Along with the warranty claim was a note recommending that the factory check how the assembly line person was installing the alternators and fan drive belts.

Quality assurance personnel, as well as the assembly line supervisors, were informed of the fan belt drive alignment concern. Mechanical lift manufacturing's quality assurance and assembly line personnel teamed together and reviewed their process. The mechanical lift assembly process appeared to be unchanged from previous years of production with one exception. The exception was a diesel engine change. The new diesel engine was powering the machine that was overheating in the field. The mechanical lift quality and assembly line supervisor concluded that the new engine was the cause of their trouble. Together the quality and assembly managers called the diesel engine

manufacture. This author was brought onto the call and informed of the concerns. They requested the diesel engine supplier's assistance in determining the cause for the fan belt drive miss-alignment.

This project document reports the problem solving process that would identify and correct a problem between an engine supplier and a mechanical lift manufacturer. A mechanical lift manufacturer had informed the diesel engine company where this author is employed. Their mechanical lift products were experiencing fan belt drive problems. The diesel engine fan belt would not track true on the associated pulleys within fan drive. The mechanical lift customer contacted the mechanical lift dealership that sold him the mechanical lift to inform him of the engine problem and ask for help determining the cause for the overheating engine. All of the communication between mechanical lift customer and the mechanical lift dealer and mechanical lift manufacturer had been by either telephone or in person. This author was given the assignment to make whatever contacts were necessary to identify the complaint, implement the steps to identify the problem, determine the cause of the mechanical problem, place into action a temporary solution, determine the final solution and implement the long term corrective action steps.

Once the true cause of the problem was identified, a presentation was created and supplied to the Mechanical Lift Company in both

electronic and paper form. McLellan (1998) encouraged, "training programs consider include finding a balance between virtual and real encounters, between synchronous (real-time) and asynchronous (delayed) communication online, in finding the best mix of communication options (text, audio, video, etc.)" (p.45). The root cause of the problem was occurring during assembly of the pulley onto the alternator by the mechanical lift assembly-line personnel. The necessity of the Mechanical Lift Company and its employees grasping the presentation and learning would be key. Raths (2001) stated, "getting the employees revved up about e-learning can be difficult" (p.45). Everyone viewed the presentation and preformed the assembly as outlined within the presentation. The test of the effectiveness of the presentation has been time and the results since the presentation has been no repeat of the fan belt jumping off of the fan pulleys.

### Methodology

The steps taken within this project involved the search for the root cause, identify the correction to be implemented and present training to prevent future problems. The project considered the business operational characteristics between team members to find a common ground to work from. Characteristics such as what forms of communications, the environment of the individuals to be trained and

the identification of who would be a recipient of distance learning were addressed. Various facets available for communications ranged from an in-person discussion to electronically transferring of data. Email was selected as a means of transferring questions, gathering data and generally enabling information to be shared between team members quickly.

Research and background information of this project began with a Mechanical Lift machine that required fan belt repairs approximately every 100 hours of operation. Though the repairs were not costly to complete, the overheating engine was counter productive. The inconvenience of down time and lost productivity lowered the machine's value to the owner. Our staff was informed about the problem when the customer became disappointed with the machine and machine's limited productivity. The operator stated that he constantly was reinstalling a fan belt. The downtime due to engine overheating and cost of a new fan belt caused this owner to contact the Mechanical Lift machine dealership for assistance.

Gathering data pertinent to the problem was accomplished through the use of telephone, faxing documents, email, US Postal services, and personal contact. The team members discussed the possibilities that a computer and electronic communication aids might detract from the process. Individuals who opposed the use of computers

(two individuals) were contacted by fax, telephone, or in person. Personal computers and electronic communication (email) enabled this project to reach its conclusion rapidly. A key benefit was the transfer of photos between teammates and associates. The color photos were quickly processed and enabled team members to add comments and arrows to aid in the fact-finding steps. Communications software provided email, business contacts, a tasks bar and calendar for scheduling. Within the task options, a file allowed a chronicle record of email messages related to this project.

The transaction of information between project team members enabled Root Cause Analysis process and training of the key mechanical lift employees through distance learning. Root Cause Analysis provided a means of overcoming problems encountered. An example of such a challenge was implementing the necessary steps to determine the true cause of the problem. This author called the Mechanical Lift Manufacture engineer and together we contacted the servicing dealership. The customer thought that the correction was the replacement of the fan belt, the mechanical lift technician thought the correction was pulley alignment, each as we show further in this document were only a temporary fix. After this initial telephone call, we worked with email messages with the understanding that we were not limited to email and could be reached by telephone.

A form of a Gantt chart was created to ensure the progress of the project. "A form of a Gantt chart will provide an individual with the means to monitor the progress of the project and ensure that key facilities of the project are not overlook" (Smaldino, 1996) (P.45). The chart listed all of the resources, identified tasks and listing whom was to be responsible for each of the tasks. This author printed a copy from his computer and shared this document with team members. This scheduling chart was key to this project due to the limitations of team member's time commitment and the distance between those associated with this project. Project team members balanced normal work related responsibilities during a normal day outside this particular project. Project manager software provided the project team a chart of project tasks, linkd the tasks to individuals and monitored their progress (Appendix, P.47).

From the Gantt chart, tasks were assigned to individuals best suited for that task. This author utilized email messages to issue tasks and gather information from team members as well as resources outside of the team. Benefits of email were a dialog providing a trail of correspondence (Appendix, P.55-62) for team members to reference and support their conclusions. Electronic communication provided a means to transmit data and digital color photos. Clarity of the electronic messages was much better than a general fax that arrives in black and



white and at times in poor resolution. Electronic communication allowed team members associated with the project a quick means of relaying messages and the ability to process the messages throughout the day.

The problem-solving tool that the project utilized was a form of "Root Cause Analysis and Corrective Action" outline. The Root Cause Analysis tool is a process for finding the true cause of the event or problem. In this process an individual can identify and record the contributing causes, the root cause, provide corrective action step(s) and the means of assessing of the corrective action steps to prevent recurrence of the problem.

An analysis of data collected from the email messages determined the cause for the fan belt dislodging from the fan pulleys. Data gleaned from the email messages was placed into a Root Cause Analysis worksheet. Root Cause Analysis was implemented within this project and an outline form can be found in the Appendix (P.48-51). Implementing the necessary steps to determine the true cause of the problem and identify the necessary corrective steps, as replacing the fan belt was only a temporary fix. The mechanical lift operator had not truly identified the cause for the fan belt to jump off of the pulley and causing the engine cooling system to overheat.

We may have experienced a form of this tool as we grew-up with our parents. Remember as a child when something went wrong, your

parents might ask you two questions; 1) "What did you do?" and 2) "What did you learn from your mistake so you can avoid a repeat?" A similar question can be applied within problem analysis, as the problem must be first identified before it can be corrected. Identifying and correcting the root cause of the problem enables businesses to survive and prosper. The Root Cause Analysis process will break down a problem into component causes. Once the root cause has been identified the team can select the best options available for the effective corrective action and implement those steps (refer to Root Cause Analysis flow chart in the Appendix, P.49).

A Root Cause Analysis and Corrective Action process has the potential to provide value beyond the industrial application. The Root Cause Analysis and Corrective Action process can be applied to solve any problem whether the challenge is at work, classroom, or in your personal life. To test the root cause identified by the team you ask the question of "why". A cause that contributed to the event/problem but by itself would not have caused the event/problem is not the root cause (Appendix, P.48) outlines the Root Cause & Corrective Flow Chart). As in every problem-solving tool, the goal is to correct the problem and prevent reoccurrence of the problems/challenges.

Root Cause Analysis can be completed individually or by a group of individuals closely associated with the problem. In this project the high

number of individuals led us to identify key players. How the project's team was formulated focused on those individuals who had a vested interest in the solution of the problem. A team concept provided a blend of knowledge and experience of how the machine was built and its operational characteristics. Team members were the customer who reported the problem, repair dealership, equipment assembly manufacturer and generally those individuals immediately involved with the event/problem.

Formation of the investigative team included this author, sales account manager, servicing dealer, mechanical lift customer, diesel engine design engineer, and the mechanical lift manufacture engineer. Our investigative team utilized the knowledge of the members of the team as well as, diesel engine production engineering, mechanical lift quality engineering and the mechanical lift assembly line supervisors. A good blend of knowledge and vested interest determined the length of time and effectiveness the process took. The project began once the team members were identified and the team obtained a problem consensus. A key point, every member was responsible to check the progress of the project on a regular basis by means of email or conference telephone call. The time frame of these conference calls was scheduled on a regular basis determined by the team (our project team conference calls were held weekly).

One of the challenges encountered during this project was when a member of the investigative team received a promotion or re-assignment (changed jobs) and was unable to maintain a vested interest in the project problem. When a team is built with an individual who does not have a vested interest in the project, the project may take longer and investigations generally might not be as thorough. When the investigative team identifies a team member's lack of focus, a replacement for that member is sourced from the departing member's supervisor. The investigative team should include individuals who can provide the necessary resources to thoroughly understand the problem, assist with the root cause analysis, and implement the corrective action process. Once the team is selected the investigative team will stay to the conclusion of the project, other individuals can be added or removed to the team as resources when necessary.

Assignments were recorded and a follow-up email was sent to both the investigative team and supervisors listing the steps to be taken and planned schedule with planned dates of completion. Email messages provided the team with a valuable tool to monitor; 1) description of the assignment/task, 2) who was assigned the task, 3) a deadline for the task and scheduling, and 4) a means of recording the project's progress. A list was tabulated from the contributing causes collected while investigating the problem. When contributing causes were identified, the

root analysis questions were asked (Appendix, p.48, Root Cause and Corrective Action Plan). The Root Cause Analysis question would be asked until the fundamental cause for the problem was identified (last cause in the chain of contributing causes). In our project, a short-term solution was applied until a long term (permanent solution) could be identified.

This project was challenged, as few studies have been documented, to combine a problem solving process, distance learning, and effective steps on how to motivate students to learn through distant learning. Current corporate literature and training publications on distance learning and steps to motivate students were examined. A key factor is to "know thy user", notes Shank, (2001) (p.45). Shank recommends determining the best means for communicating and the form of distant training to ensure effective learning. A key to this project is that communication and learning is not unique to the classroom. "In many educational applications, it would be more worthwhile to worry about other things that waste time on technology" (Kearsley, 1998) (p.45). Trainers had to recognize characteristics that motivate the learner and develop the lesson plan to fit those characteristics and their student environment. An effective presentation does not need to use all of the bells and whistles to facilitate effective learning.

The segment of this project that questions the effectiveness of distant learning is the mechanical lift customer. The mechanical lift customer spoke to the mechanical lift dealership and explained problem as best he could and the dealership advised him to reinstall the fan belt. The dealer provided a simple fix without observing the problem. The customer provided a description of the problem however in the translation the intended message was not heard and the mechanical lift dealership gave a wrong correction.

#### Project Review

The subject of this project was a Mechanical Lift machine that required fan belt repairs approximately every 100 hours of operation. Though the repairs were not major they were counter productive by causing down time and devaluing the owner/operator's opinion of the machine. The machine's cooling system for the engine would over heat due to its fan belt jumping-off of the fan belt pulleys. The customer would inspect his machine and observe that the fan belt was not in its proper operating position, re-install the fan belt, allow the machine to cool and once cooled he would continue operating the machine.

With the fan belt operating as designed, the engine would cool properly and the customer thought the problem had been fixed. But later the fan belt would jump-off of the fan pulley and the engine would get hot (temperature gauge would read in the red). The customer was sure

he could fix the problem by simply reinstalling the fan belt. This identifies one of this project's challenges, as the customer was not truly fixing the problem, as the problem would occur again. The replacement of the fan belt onto the fan pulley, though repair appeared to be the permanent fix, the customer had not truly identified the true cause for the fan belt jumping off of the fan drive pulleys and causing the engine's cooling system to overheat.

The owner of the Mechanical Lift machine called his local dealership to repair the Mechanical Lift machine after the third time the fan belt jump-off the pulleys. The Mechanical Lift dealership noted all of the customer's comments and referenced the history service library on the diesel engines. Within the technician's library a bulletin was found (Appendix, p.52-54) discussing alignment of the alternator and the drive pulleys. The service man, armed with his tools and the increased knowledge, inspected the overheating equipment. When the service technician had returned to the Mechanical Lift dealership he notified his supervisor of the steps necessary to correct the problem and explained what caused the Mechanical Lift machine to overheat. Alignment of the alternator to the other pulleys in the fan belt drive caused the fan belt to jump off of the alternator pulley and the fan stop turning. After the alternator/alternator pulley was correctly re-aligned with associated drive pulleys and a new fan belt installed, the customer was satisfied

with the performance of Mechanical Lift machine. A warranty claim for parts and labor of the two repairs was submitted to the manufacture of the mechanical lift. Along with the warranty claim was a note recommending that the factory check how the assembly line person was installing the alternators and fan drive belts. The quality manager of the Mechanical Lift Machine Company reviewed the assembly line personnel and contacted the diesel engine supplier for assistance when determine the true cause.

With this problem occurring on several machines each had been treated as unique problems. The Mechanical Lift Manufacture never observed or investigated the overheating problem on a boarder scale. Once the Mechanical Lift manufacture noticed a trend in the failure, assignments had been issued. The Mechanical Lift manufacture's service department collects reports from the field on the reliability of their product and reviews these lists to determine whether the problems are single cases or a trend for additional problems. The Mechanical Lift manufacture received three reports from their customers. The report was that the fan belts jump-off the fan pulleys. The Mechanical Lift manufacture's service department contacted the production line to report the problem their customers were experiencing and to review the machine's assembly process. The Mechanical Lift manufacture's service and production people reviewed the data from the customers and



determined that the final repair/fix at the customer sites had been to install a new fan belt and correcting the pulley alignment. In the data reports the Mechanical Lift dealership service people sent to the engine manufacture had identified the fan belt was too critical of alternator pulley alignment. In the repair statements from the field, the correction had always been to install a new/old belt with no reference to the alternator pulley alignment.

The report from the Mechanical Lift Company asked for corrective action or they would purchase engines from another engine manufacture. Telephone calls were not providing the necessary means to transfer material/information between parties. A meeting had to be held to allow both parties to transfer information. In the first of many meetings, the Engine Supplier and Mechanical Lift manufacture discussed and identified the key individuals to be instrumental in the investigation and corrective action implementation. During the review meeting the production line people identified that they installed the alternator to the diesel engine but the alternators were installed as in the past. Production line people reacted quickly and contacted the engine supplier to report that fan belts were jumping off of the fan and alternator drive pulleys due to the alternator pulley alignment error.

Once the Diesel Engine Company had been informed of the non-compliance, this author was assigned the task to identify the true cause

and implement the corrective steps. He established a conference call to begin the communications (speakerphones enabled several individuals to be involved). The telecommunications enabled the involved parties to agree upon a common ground for future communications. The range of individual communication resources ranged from a workstation telephone, pager, cellular phone, fax, computer access and an assembly line supervisor as means of communicating. One of the challenges to the group was that even though each individual was eager to find the solution to the overheating problem, no one had access to a telephone throughout the entire day.

The Diesel Engine Supplier listened to the customer, the Mechanical Lift manufacture and began research in the cause of the fan belt alignment. The Diesel Engine manufacture observed that it supplied a pulley but did not assemble the alternator to the diesel engine. Engineering from the engine supplier reminded the Mechanical Lift manufacture that the engine supplier did not provide the alternator or install the alternator onto the diesel engine. The Diesel Engine supplier did supply the alternator pulley and fan belt but not the alternator (Appendix, p.63). The recommendation from the engine supplier was to the Mechanical Lift manufacture assembly line to install the pulley and alternator correctly onto the engine and that would cure the problem.

During the conference call, a secondary form of communication was discussed and email was selected. A key factor in the project's success was our focus on distant communication, distant learning, and how to utilize the technology resources team members are familiar with and willing to utilize. A consensus was obtained that email messages and a weekly conference call would be a basis to work from. The project team agreed to schedule conference calls once a week to ensure every team member's level of understanding and project status. Between conference calls, individuals on the team would telephone, leave voicemail messages, and utilize the email services.

How did the computer and the electronic communication aid or detract from the process? This author believes that the computer and electronic communication enabled this project to come to its conclusion more rapidly. A key benefit was the transfer of photos between teammates and associates via email messages. The color photos (digitally transmitted) were quickly processed and enabled team members to add comments and identifiers such as arrows to digital photos to aid in understanding during the fact-finding steps (Appendix, p.63-73).

Methods of communicating within a company could be a challenge even without adding time zone changes. For example, a very effective tool to assist team members is the use of a fax machine. The ability to transfer a piece of paper to the client and then place a telephone call to

key team members using the faxed document as an agenda or a reference. A drawback with the fax documents is that the quality of the document suffers with each transmission, especially a document with photographs.

Our conference call had allowed each of major players to list the key individual's email address, key telephone (some listed alternative numbers such as cellular phone numbers), and fax numbers. Personal data gleaned from the conference call was entered into this author's computer. The electronic software loaded on his computer would afford him the contact information in the computer files for reference, email messages, tasks, and a form of a Gantt chart (Appendix, p.47).

Consensus among the team members was that email would allow members to communicate at any time of the day and be flexible enough to fit into everyone's busy schedules. Electronic communications (email) provided a means of transferring information when team members are separated by time, distance, and various levels of technology. This author utilized email when he sent a message that summarized our conference calls. He sent a summary of each conference call to each of the individuals involved in this project. Email messages were also used to assign tasks and respond to questions (Appendix, p.55-62).

Office environments today rely on email messages as often as the telephone. Early in the project, members discussed what forms of

communication (telephone, fax, or email) were available to each member of the team. Each member indicated that he/she had access to email however the assembly line individuals commented that their access was limited. Their assembly line supervisors volunteered to make paper copies and review with the assembly line individuals.

A challenge the team members experienced with electronic communication was when a message (email) was sent without a copy to every team member. Team members were not synchronized when not copying the entire team. Individuals of the team who were forgotten (not copied) from the email did not stay current. The project efforts would become fragmented and require time at the start of every conference call to check every member's understanding of the project status. To ensure the project's progress was not faulted, a weekly conference call was scheduled. A team member volunteered to record the key points during our conference call and copy each team member with a follow-up email message.

Once the tasks were assigned the members agreed on a date and time to schedule the next conference call. Throughout the week, individuals of the team would be communicating questions and sharing the answers. Members would be in contact with each other throughout the days before the next telephone conference call discussing assignments. A key purpose of the conference call was to ensure that

every team member had the same data and understood the overall plans and steps necessary to a satisfactory solution.

The information gathering began with a simple statement of the problem/event; what was the customer's concern? The mechanical lift manufacture reported that the diesel engine coolant temperature would rise to a hazardous point. The operator became concerned when the temperature gauge on the control panel indicated the temperature was in the red zone. The project's Event question was "Why does the diesel engine coolant temperature rise into the red zone"?

The problem-solving tool the project utilized was a form of a "Root Cause Analysis and Corrective Action" outline. The Root Cause Analysis tool is a process for finding the true cause of the event or problem. In this process an individual can identify and record the contributing causes, the root cause, provide corrective action step(s), and the means of assessing the corrective action steps to prevent recurrence of the problem.

An analysis of data collected from the email messages determined the cause for the fan belt dislodging from the fan pulleys. Data gleaned from the email messages was placed into the Root Cause Analysis process. Root Cause Analysis was implemented within this project and an outline form can be found in Appendix (p.48). The team implemented the necessary steps to determine the true cause of the problem and

identifying the necessary corrective steps, as replacing the fan belt was only a temporary fix. The mechanical lift operator had not truly identified the cause for the fan belt to jump off of the pulley, causing the engine cooling system to overheat.

Our process tool asked questions such as, "why did the diesel engine operate so warm?" The mechanical lift customer reported that the fan belt walked off of the fan drive pulleys. The Direct Cause: the diesel engine's fan belt walked-off of the fan drive pulley. A Contributing Cause: only the fan belt was damaged. Short Term Correction: reinstall the fan belt onto the fan drive pulleys. The mechanical lift customer's concern was, "the diesel engine operates in the red zone and the fan belt walks off of the fan pulley when the engine is operating." The team's event question: "Why does the diesel engine coolant rise into the red zone?"

Once we had the simple statement of the event, "Why does the engine coolant get hot?", we began collecting data. A key point about gathering data is the longer you wait the harder it is to collect the necessary data. When possible, go to the scene to take notes or enlist a reliable source to visit the site and record their observations. Two of the team members had been present at the time of the engine operating in the red zone and belt walking-off. Both individuals had taken mental notes and were asked to record their observations.

Team members organized the data gleaned from the Mechanical Lift equipment customer and repairman. This data was inserted under headers titled: 1) Event, 2) Direct Cause, 3) Contributing Cause and 4) Root Cause. The team asks the question “why” of each contributing cause to determine the root cause. The team searched for the reason why an outcome happened. The first attempt to organizing the data was as follows:

Event: The mechanical lift customer was performing daily tasks with the machine when the diesel engine began to operate hot (operates in the red zone on temperature gauge). Customer did not remember any unusual conditions or tasks that might cause the fan belt to dislodge from the fan drive pulleys.

- Direct Cause: The fan belt will not stay on the fan drive pulleys.
- Contributing Cause: The fan belt is not broken.
- Contributing Cause: The fan belt shows signs of disengaging the fan drive pulleys but could be reused.
- Contributing Cause: The fan drive pulleys are not damage or defective.
- Contributing Cause: The fan belt tension when assembled on the fan drive pulleys is within the correct range.



- Contributing Cause: The fan belt is installed onto the fan drive pulleys on the Mechanical Lift machine and the machine will cool.
- Root Cause: Cannot be identified based on the Contributing Causes listed above.

The customer supported this statement as the owner reinstalled the fan drive belt only to have the fan belt dislodge and the engine overheat. Then the team members asked the question; "why would this contributing factor cause the fan belt to jump off the pulleys?" The team was required to revisit the problem site to observe and ask more questions. The team scheduled a conference telephone call with the mechanical lift dealership technician during his visit to the mechanical lift customer site.

The Mechanical Lift machine dealership's repair department was alerted of the problem and scheduled a man to inspect and repair the excavating company's machine. The Mechanical Lift Equipment dealership's service man inspected the machine and spoke to the owner and operators of that machine to accumulate background information. The Mechanical Lift Equipment dealership service man made the same observation as the owner/operator and replaced the fan belt but the serviceman watched the operation of the machine and the fan belt. The technician made reference to the Product Support Bulletin (Appendix,

p.52-54), which focused on the proper alignment of drive pulley and mounting of the alternator to engine. The Mechanical Lift machine dealership's service man observed that the fan belt and the fan pulleys were not in alignment. The machine was shutdown once again and the alternator shimmed to correctly align the pulley on the alternator with all of the other fan drive pulleys. The fan belt was replaced and the machine operated to watch the fan belt. On this machine the fan belt never jumped off the pulleys again, the cause of the fan belt jumping off of the fan pulleys was the pulleys' alignment.

These are the contributing factors as found by the mechanical lift technician at the mechanical lift customer site:

- Direct Cause: The fan belt will not stay on the fan drive pulleys.
- Contributing Cause 1: The fan belt would jump off of the fan drive pulleys approximately after 500 hours of operation.
- Contributing Cause 2: The fan belt is not broken.
- Contributing Cause 3: The fan belt shows signs of disengaging the fan drive pulleys but can be reused.
- Contributing Cause 4: The fan drive pulleys are not damage or defective.
- Contributing Cause 5: The fan belt tension when assembled is within the correct range.

- Contributing Cause 6: The fan belt is installed onto the fan drive pulleys at the mechanical lift factory.
- Contributing Cause 7: The alternator is the same part as supplied with Mechanical Lift machine.
- Contributing Cause 8: No object is rubbing on belt or causing it to jump off the pulleys.
- Contributing Cause 9: Mechanical lift is operated as recommended in the operator's manual.
- Contributing Cause 10: Alternator is mounted as outlined in technical manual.
- Contributing Cause 11: Not all of fan belt drive pulleys were within 2 millimeters of alignment (the alternator pulley was out of alignment specifications).
- Root Cause: Root Cause could not be identified based on the Contributing Causes listed above. Diesel Engine manufacture specifications required the fan belt pulleys must be aligned to prevent the fan drive belt from being dislodged.

The project team reviewed the contributing causes and identified number eleven as a possible root cause. The project team directed the mechanical lift technician to add shim washers to the alternator mounting until the fan drive was properly aligned. Once the alignment of the fan belt drive pulleys was within specifications the fan belt was re-

installed and customer directed to test the repair. The mechanical lift technician's observation supported that the cooling problem had been identified. The customer was asked to operate his machine as outlined in his operator's manual and report immediately if the fan belt was to jump-off of the fan pulleys.

During the weekly conference call the project team reviewed their findings at the mechanical lift customer site and determined that a trained diesel engine technician or engineer should inspect the mechanical lift at the mechanical lift factory. Consensus was obtained to schedule a diesel engine distributor's technician (located near the mechanical lift factory) to inspect any of the new Mechanical Lift machines that experienced the failure at the mechanical lift factory. Both the diesel engine and mechanical lift team members were assigned the task of obtaining information to provide the assigned engine distributor's technician prior to his trip to inspect the failed Mechanical Lift machine. Team members agreed to organize a conference call during the engine distributor's technician visit. These are the contributing factors as found by the mechanical lift engineer, mechanical lift assembly personnel and the engine distributor's technician:

- Direct Cause: The fan belt will not stay on the fan drive pulleys.
- Contributing Cause 1: The fan belt would jump off of the fan drive pulleys approximately after .5 hours of operation.

- Contributing Cause 2: The fan belt is not broken.
- Contributing Cause 3: The fan belt shows signs of disengaging the fan drive pulleys but could be reused.
- Contributing Cause 4: The fan drive pulleys were not damaged or defective.
- Contributing Cause 5: The fan belt tension when assembled is within the correct range.
- Contributing Cause 6: The fan belt is installed onto the fan drive pulleys at the mechanical lift factory.
- Contributing Cause 7: The alternator is purchased separately from the diesel engine.
- Contributing Cause 8: Mechanical lift assembly line personnel install the alternator onto the diesel engine.
- Contributing Cause 9: No object is rubbing on belt or causing it to jump off the pulleys.
- Contributing Cause 10: Mechanical lift is operated as recommended in the operator's manual.
- Contributing Cause 11: Alternator is mounted as outlined in Mechanical Lift assembly instructions.

- Contributing Cause 12: Not all of fan belt drive pulleys were within 2 millimeters of alignment (the alternator pulley was out of alignment specifications).
- Contributing Cause 13: Mechanical Lift machine has option of two difference diesel engines.
- Contributing Cause 14: Each diesel engine takes different alternator part.
- Contributing Cause 15: Assembly line instructions do not require shims added to the alternator mounting.
- Contributing Cause 16: Assembly line instructions do not require a pulley alignment check.
- Root Cause: Could not be identified based on the Contributing Causes listed above.

The project team reviewed the information they had available and determined that additional data must be collected to enable the team to identify the Root Cause of this failure. After asking the question: "would this contributing factor cause the fan belt to jump off of the fan drive pulleys?" The team determined that the root cause had not been found. A trained engine serviceman was informed of the risk and asked to investigate, make the necessary repair, and report to the committee. The service man made his inspection and determined that the alternator was not properly shimmed and added shims to align the pulleys for the fan

belt to ride. The team did agree that a short-term correction could be applied. Team members were given assignments and the conference call ended.

- Short Term Correction: Follow a Service Bulletin to shim the alternator, positioning the alternator so all fan drive pulleys were aligned (refer to the attached service bulletin).

To assist in the collection of background data and contributing factors the diesel engine manufacture agreed to travel to the mechanical lift manufacture's site. Together, the diesel engine distributor and mechanical lift manufacture would inspect the unit that the fan belt jumped off after one hour of operation.

Team members were also given tasks to secure data for the next conference call. An assignment for the mechanical lift factory engineers was to provide the team members with digital photographs of the diesel engine at various stages of the installation of the alternator and the fan belt. Kodak film advertisements state, "A photograph is worth a thousand words." A digital photograph provides a thousand words in a matter of minutes. Team members communicated between associates with the use of digital photos and text to support the digital photo (Appendix, p.63-73).

The Project Team collected the following contributing factors from all aspects of this project when the diesel engine distributor visited the mechanical lift manufacture:

- Direct Cause: The fan belt will not stay on the fan drive pulleys.
- Contributing Cause 1: The fan belt would jump off of the fan drive pulleys, ranging from .5 to 500 hours of operation.
- Contributing Cause 2: The fan belt is not broken.
- Contributing Cause 3: The fan belt shows signs of disengaging the fan drive pulleys but can be reused.
- Contributing Cause 4: The fan drive pulleys are not damaged or defective.
- Contributing Cause 5: The fan belt tension when assembled is within the correct range.
- Contributing Cause 6: The fan belt is installed onto the fan drive pulleys at the mechanical lift factory.
- Contributing Cause 7: The alternator is the same part as supplied with Mechanical Lift machine.
- Contributing Cause 8: No object is rubbing on belt or causing it to jump off the pulleys.
- Contributing Cause 9: Mechanical lift is operated as recommended in the operator's manual.



- Contributing Cause 10: Alternator is mounted as outlined in technical manual.
- Contributing Cause 11: The fan belt drive pulleys are within 2 millimeters of alignment.
- Contributing Cause 12: Diesel engine would overheat (temperature gauge needle showed in the red zone)
- Contributing Cause 13: The fan belt jumped off of the fan drive pulleys and fan stop turning
- Contributing Cause 14: The fan belt may not be damaged when inspected after belt jumped off pulleys.
- Contributing Cause 15: Fan belt has an automatic tension arm and is set at proper tension.
- Contributing Cause 16: Fan belt would jump off the pulleys within a range of 1 to 500 hours of operation.
- Contributing Cause 17: Alternator pulley was not in alignment with fan belt drive assembly (other 4 pulleys).
- Contributing Cause 18: Mechanical lift manufacture supplied the alternator.
- Contributing Cause 19: Diesel engine manufacture supplied engine less alternator but installed brackets.

- Contributing Cause 20: Diesel engine manufacture supplied the fan belt, alternator pulley and alternator mounting hardware (pulley parts and miscellaneous mounting hardware were in a bag taped to engine).
- Contributing Cause 21: Diesel engine manufacture did not supply installation instructions for alternator pulley.
- Contributing Cause 22: Mechanical lift manufacture installed the alternator drive pulley onto the alternator.
- Contributing Cause 23: Mechanical lift manufacture's assembly line personnel were mixing alternator pulley parts from another brand of diesel engines (parts are not identical between engine manufactures).
- Contributing Cause 24: Mechanical lift manufacture installed the alternator to the engine.
- Contributing Cause 25: Mechanical lift manufacture installed the fan belt onto the drive pulleys.
- Contributing Cause 26: Mechanical lift manufacture assembly line person would check assembly and tension of belt.
- Root Cause: Identified as Contributing Cause line item #23 listed above.

The wrong alternator pulley was installed on the alternator due to an assembly line person's lack of training. The corrective action for this

project was to install the correct alternator pulley per diesel engine engineer guidelines (do not mix other supplier parts).

- Long Term Solution: Mechanical Lift Manufacture's assembly line individual to install the parts supplied with the diesel engine (parts in the attached bag of hardware). Diesel engine supplier will provide a set of instructions for mechanical lift assembly-line personnel to train and post next to the assembly station (Appendix, p.72). Implement training for the mechanical lift assembly line individuals on parts identification and the installation procedure (Appendix, p.74-80).

To test the team's conclusion, the following chain of events were implemented:

- 1) Customer and service dealership in the field were questioned on their corrective steps on each machine.
- 2) Servicing dealership was asked to describe what they observed prior to repairs and corrective steps were implemented.
- 3) Mechanical Lift manufacture's service and engineering departments were asked the same questions as the servicing dealership.
- 4) Mechanical Lift manufacture's assembly line supervisor and lines people were asked to list the procedures involved with the fan belt and alternator during assembly.

- 5) Mechanical Lift manufacture's assembly line people were asked of oddities or irregularities that might require special or individual assembly procedures.

Training PowerPoint slides outlining the assembly process of the alternator onto the John Deere engine were measured for effectiveness.

In this project four different types of evaluations were considered:

- 1) A question sheet at the end of the class (perhaps the most commonly used in classroom training)
- 2) A pre-training questionnaire and a post-training questionnaire
- 3) Implement steps to determine if the information learned is being applied (is the job performed as designed or is there still problems)
- 4) Measure the ROI (return on investment), comparing the monetary value of the results with the cost of the training.

A key to measuring competency is to have a benchmark. The project researched the assembly line process of installing the alternator during the "Root Cause Analysis." A benchmark assembly process, identified before the training, was necessary to determine what you want to correct/improve. The "Root Cause Analysis" identified that assembly line individuals were not consistent and the assembly of the alternator to the engine involved using wrong parts.

The final segment of this project that questions the effectiveness of distant learning involves the mechanical lift customer. The mechanical lift customer spoke to the mechanical lift dealership and explained problem as best he could and the dealership advised him to reinstall the fan belt. The dealer provided a simple fix but that message did not correct the root cause for the fan belt to become dislodged. The customer provided a description of the problem however in the translation, the intended message was not heard and the mechanical lift dealership implemented the wrong correction.

The United States Distance Learning Association (1997) stated that: "Faced with retraining fifty million American workers, corporate America is using distance learning for all aspects of training both internally and externally. Many major corporations such as Hewlett-Packard save millions of dollars each year using distance education to train employees more effectively and more efficiently than with conventional methods" (p.45). This project was challenged with distance between the customer, the mechanical lift factory, the diesel engine supplier, and the product support for the diesel engines as well as training in the most cost-effective manor.

In most office environments today, co-workers rely on email messages as often as the telephone. Early in this project members discussed what forms of communication (telephone, fax, or email) were

available to the team members. Each member indicated access to email however the assembly line individuals commented that the access was limited. Their assembly line supervisors volunteered to make paper copies and review with the assembly line individuals. These same constraints were observed when preparing the training for the Mechanical Lift assembly line personnel.

Training was developed for the proper selection of an alternator drive pulley and its installation onto the alternator. The presentation was supplied to the Mechanical Lift Company in both paper and electronic form (Appendix, p.74-80). Westera and Sloep (1998) report, "the learning environment should resemble real life in as many respects as possible" (p.45). The paper copy allowed the assembly line supervisor to post the instructions next to the assembly line workstation. An electronic copy of the presentation was stored on the computer for future reference and copies for the workstation.

### Conclusions

Problems addressed within this project were to take the necessary steps to determine the true cause of the problem, implement corrective actions, and train key individuals to prevent reoccurrences. This project explored and discussed the following questions. What process/steps were necessary to identify the true cause of the overheating? How could

distance communication/learning be utilized to determine the cause of the failure and assist in preventing the identified problem from reoccurring?

Prior to this project the end-user was satisfied with the performance of his machine. However, when the engine began to overheat the customer's satisfaction began to wane. The customer would inspect his machine and observe that the fan belt was not in its proper operating position. The customer would replace the fan belt and allow the machine to cool. Once the machine's engine cooled he continued to operate his machine. With the fan belt operating as designed the engine would cool properly and the customer thought the problem was fixed. The customer had only repaired the symptom as later the fan belt would jump-off of the fan pulley and the engine would get hot (temperature gauge would read in the red). The customer had been sure he could fix the problem by simply reinstalling the fan belt. The customer was not truly fixing the problem, as the problem would repeat. Once the pulley alignment was repaired so that the fan belt would stay on the pulleys the engine would not overheat. The machine's cooling system for the engine would over heat due to the fan belt jump-off of the fan belt pulleys.

Prior to understanding the problem had occurred on more than one machine, the Mechanical Lift Company treated this as a unique problem. Once the Mechanical Lift Company noticed a trend in the

failures, assignments were issued, and investigated on a boarder scale. The Mechanical Lift manufacture's service department collected reports from the field on the reliability of their product and reviewed these lists to determine whether the problems were single cases or a trend for additional problems. The team's goal was finding the true cause and eliminating the repair of the symptom. Root Cause analysis provided a tool that helped direct the team to identify the true cause for the mechanical lift engines overheating.

Finding the long-term solution to the fan belt problem had been hampered by distance, different levels of product knowledge, language barriers (regional and educational), and the inconsistency of the timing of the fan belt's jumping off the pulleys. Various forms of communication were involved as the team members related their messages. An ideal situation might have been to send key individuals to the customer's place of business. A location where machine and engineering from both the Diesel Engine Supplier and Mechanical Lift Manufacture could meet to coordinate efforts. Deterrents with the concept of a central location were inconsistency such as:

- 1) Not every machine experienced the fan belt jumping off of the pulleys.
- 2) The length of time between failures was not the same, average was at 500 hours.



- 3) Cycle times or load duty did not seem to be a factor.
- 4) Neither company had manpower available to dedicate to the time requirement to follow a specific machine.
- 5) Expenses were not in the budget.

Communications within the project involved individuals with differences in knowledge, ethnical backgrounds, and even company policy. Communication could have been limited if the team had chosen person-to-person contact or just telephone conversations. A factor within the project's success had been to focus on the human aspects of distant learning (Spitzer, 1998), utilizing the technology resources that team members were familiar with and willing to use. Our project's conclusion was reached quickly due to the blending of electronic messages (email) and telephone communications. The group consensus on conference calls (weekly), voicemail messages, and email provided a common ground for communications and were flexible to fit into everyone's busy schedules. "Electronic communications (email) provide learning opportunities when members are separated by time, space, and various levels of technology", (Keegan, 1996).

A challenge that the team members experienced and overcame was when a message (email) was sent without a copy to every team member. Team members were not synchronized when team members were omitted from email messages. Individuals of the team who were forgotten (not

copied) did not stay current. Conference calls provided the team with a means to review assignments and check on progress and eliminate potential fragmentation. To ensure the project's progress, reference was made to our Gantt chart and discussions during our weekly conference call. "A form of a Gantt chart provided members with the means to monitor the progress of the project and ensure that key facilities of the project are not overlooked" (Smaldino, 1996). Future projects for this author will have a form of a Gantt chart to ensure team members remain current as they monitor the progress of the project. Conference calls were a vehicle to ensure that every team member had the same data and understood the overall plans and steps necessary to a satisfactory solution.

Our project's success has been tested over the past eight months with no reoccurrence of the problem. The questions brought to our attention during those eight months were answered by referring to the training document showing the assembly procedure and the list and photo of the parts. Distant training is possible with the appropriate selection of tools the learner understands or is willing to learn.

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## Appendix

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## Root Cause & Corrective Action Plan

Step 1: Form your project team from individuals involved

Step 2: Attack the event by building a visual cause chain from the following 4 points:

a) Event – what is broken/problem

b) Direct Cause – The cause that directly resulted in the event (the first cause in the chain).

c) Contributing Cause(s) – A cause that contributed to an event but by itself would not have caused the event (the cause after the direct cause).

d) Root Cause – The fundamental reason for an event (the last cause in the chain).

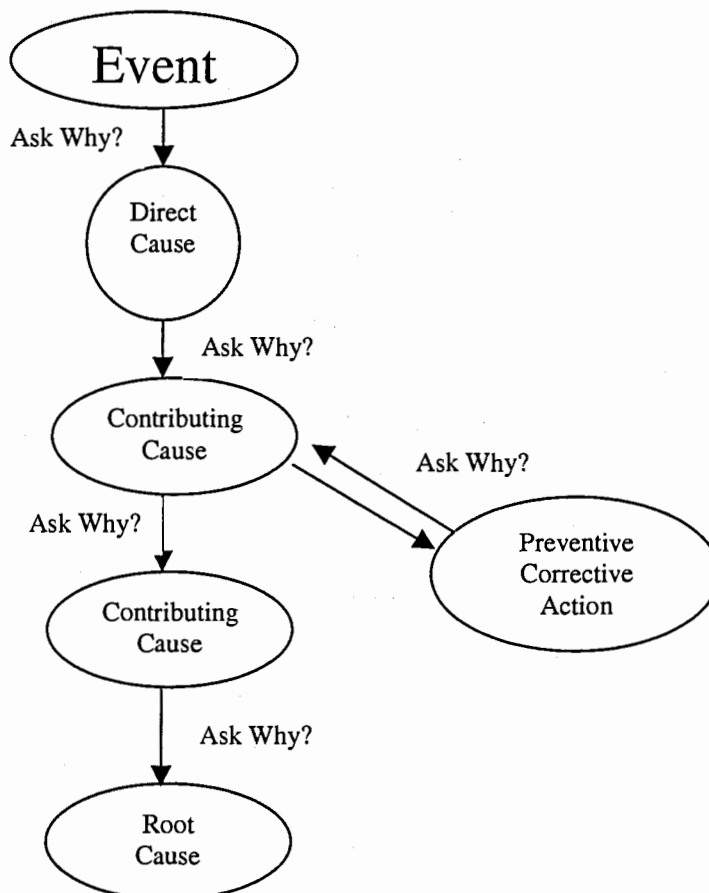
Step 3: Test the visual chain by working the chain backwards

Step 4: Break the cause chain by using the corrective actions

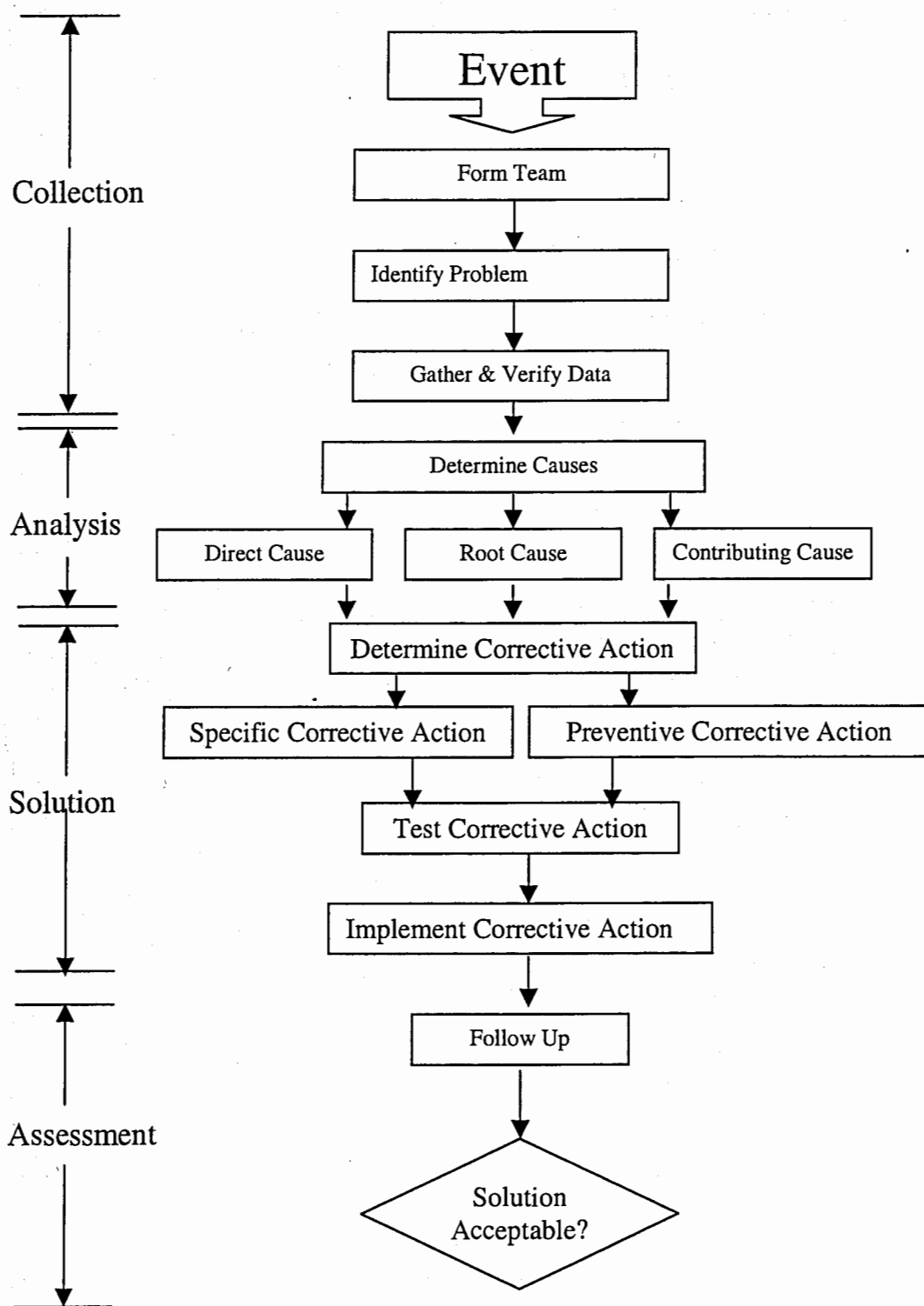
a) Specific Corrective Action – Action(s) taken to correct the direct cause and the effect.

b) Preventive Corrective Action – Action(s) taken that prevent recurrence of the event (preventive actions must address the root and contributing causes).

Step 5: Implement the corrective action



## Root Cause & Corrective Action Flow Chart



### The Root Cause Analysis Terms & Definitions

**Assessment:** An independent review to determine if the corrective actions have been effective in preventing recurrence.

**Cause:** A factor leading to an event.

**Cause Chain:** A diagram showing the causes linked in sequence from the event question to the root cause.

**Contributing Cause(s):** The causes that contributed to an event but by itself would not have caused the event (the causes after the direct cause).

**Corrective Action:** A set of planned actions implemented for the sole purpose of resolving the problem.

**Direct Cause:** The cause that directly resulted in the event (the first cause in the chain).

**Effectiveness Measurements:** The criteria used to evaluate if the corrective actions have achieved the desired outcome.

**Event:** All-inclusive term for any of the following: product failure, out of control process, audit finding, accident, customer complaint, pleasant surprise, etc.

**Event Question:** The problem, in the form of a question, that is used to start the analysis.

**Follow Up:** A review done by a team member to insure all corrective actions were implemented as stated.

**Global Issue:** Significant issues with a high probability of occurring in areas outside of the team's control.

**Natural Team:** A group of people having vested ownership of the problem to be solved.

**Preventive Corrective Action:** Action taken that prevent the recurrence of the event (preventive action must address root and contributing causes).

**Qualified Team:** The natural team, including other individuals who can provide necessary resources to understand the problem or can help in the root cause analysis and corrective action process.



**Root Cause:** The fundamental reason for an event (the last cause in the chain).

**Root Cause Analysis and Corrective Action Process:** An effective process for finding the true or actual cause of events, facilitating effective corrective action and preventing their recurrence.

**Specific Corrective Action:** Action(s) taken to correct the direct cause and the effect.

DEERE POWER SYSTEMS GROUP



DATE: 5 June 1998

FUNCTIONAL GROUP CODE: 0429

APPLIES TO: **POWERTECH® 4.5 L AND 6.8 L ENGINES WITH 226 MM AND 290 MM FAN HEIGHTS**

**OPTION CODES:**

**2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2435, 2436, 2461, 2471, 2472, 2473, AND 2474**

SUBJECT: **FAN BELT JUMPING**

DTAC SOLUTION: **K001230**

**Complaint or Symptom:**

- Fan belt walks off pulleys.
- Fan belt fails prematurely.

**Problem:**

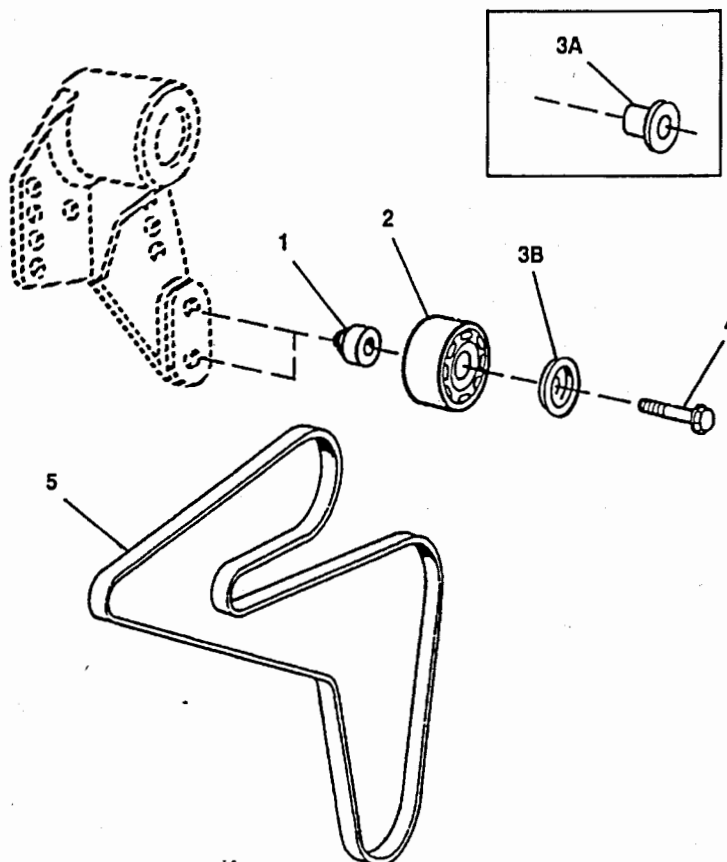
- Idler pulley out of alignment.
- Alternator pulley out of alignment.

(over)

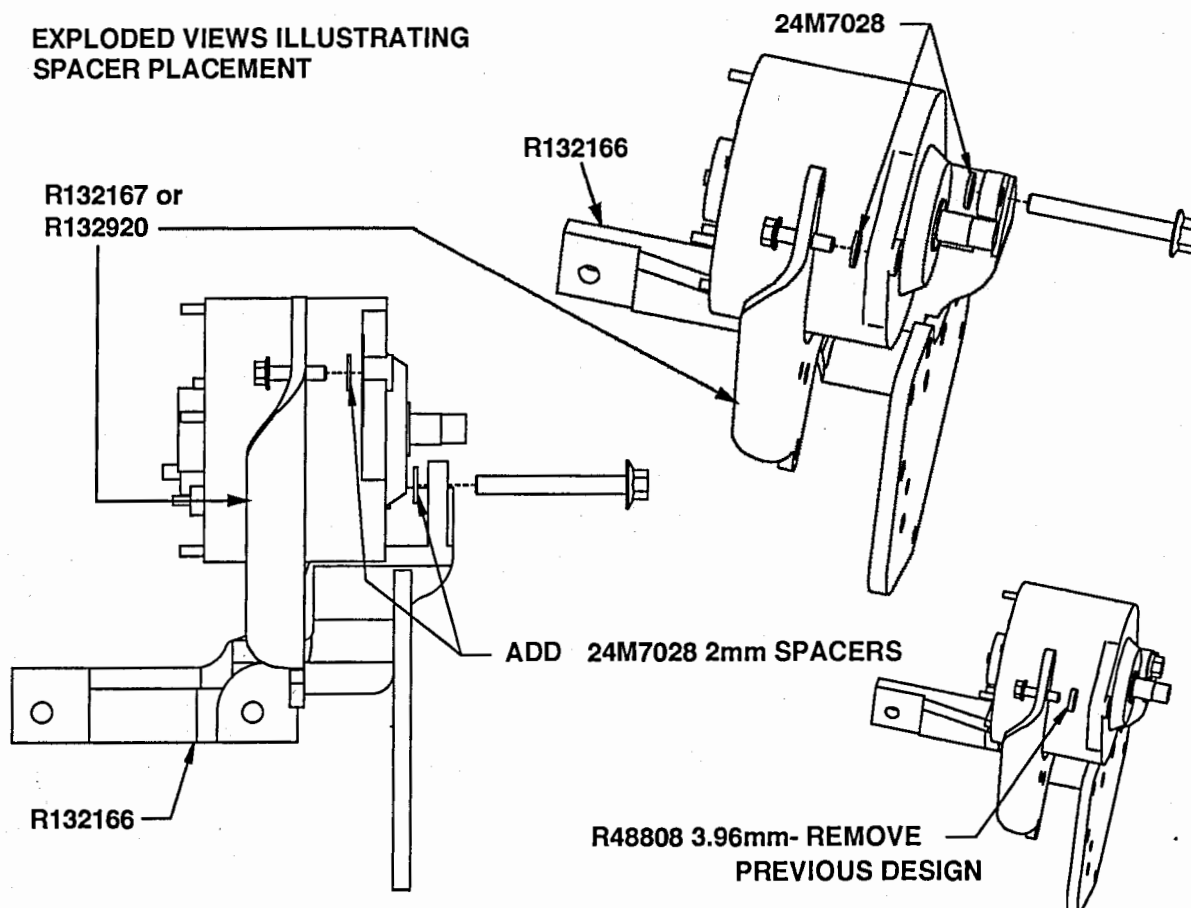


**Solution:**

Replace R500352 Cover (3B) on idler pulley with R107749 Sleeve (3A).



KEY	PART #	PART NAME	QTY	REMARKS
01	R500320	SPACER	1	(CODE 2434 THRU 2496) (SUB FOR R107654)
02	RE68722	PULLEY	1	(SUB FOR RE51281) (CODE 2434 THRU 2496)
03A01	R107749	SLEEVE	1	(CODE 2434 THRU 2496)
04 01	19M7808	SCREW	1	M10 X 65, (CODE 2434 THRU 2496)
05 01	R123456	BELT	1	X (CODE 2424, 2436)
05 02	R123441	BELT	1	X (CODE 2455)
05 03	R123469	BELT	1	X (CODE 2428) (SUB FOR R123460)
05 04	R123462	BELT	1	X (CODE 2430)
05 05	R123463	BELT	1	X (CODE 2431, 2435)
05 06	R123464	BELT	1	X (CODE 2432,2464)
05 07	R123466	BELT	1	X (CODE 2434)
05 08	R123451	BELT	1	X (CODE 2417, 2437)
05 09	R123454	BELT	1	X (CODE 2419, 2439)
05 10	R123453	BELT	1	X (CODE 2440)
05 11	R123308	BELT	1	X (CODE 2442)
05 12	R123442	BELT	1	X (CODE 2443)
05 13	R123468	BELT	1	X (CODE 2426,2444,2465,240H)
05 14	R123469	BELT	1	X (CODE 2445)
05 15	R123470	BELT	1	X (CODE 2446)
05 16	R123441	BELT	1	X (CODE 2455)

**Solution (continued):**

1. Remove the R48808 Washer between the R132167 or R132920 Alternator Bracket and the top alternator foot.
2. Install a 24M7028 Washer between the R132167 or R132920 Alternator Bracket and the top alternator foot.
3. Install 24M7028 Washer between front ear of the R132166 Alternator Bracket and the bottom alternator foot.

Example of email as a means to assign and monitor tasks

We do not install the alternator onto the engine or pulley onto the alternator

Do you remember when we experienced this problem with the customer last week? The belts were walking off due to the washers we used to mount the alternator. A 2 mm difference in thickness created the problem. Do you know if Mechanical Lift has done any changes in the mounting hardware?

I for some reason we can't speak during the morning, Carmen or Jose Juan will give you a call.

Have a great day!  
Bye!

**Elsie**  
**Quality Engineer**

Phone/Fax (xxx) xxx-xxxx  
E-mail: Elsie@engine.com

-----Original Message-----

**From:** xxxxxx David  
**Sent:** Thursday, October 05, 2000 2:42 PM  
**To:** Elsie  
**Subject:** Mechanical Lift

**Elsie,**

I spoke to Paul of Mechanical Lift and they have fan belt jumping off (we ships engine less alternator).

Al at PEC asked which alternator pulley we send with the engines?

Can you help me or do I need to provide you with more details?

Thanks,

*Dave*

Here are 2 up close pictures of the alternator. One shows the upper spacer & one shows the lower spacer.



MVC-468L.jpg



9140-3030\_0057.pdf.p

df



MVC-470L.jpg

**From:** Maria  
**Sent:** Wednesday, May 02, 2001 3:03 PM  
**To:** Dave  
**Cc:** Kevin; Christopher; Allan; Benny; Yuriko; Aaron; Ana; Evangelina; Fernando  
**Subject:** RE: Mechanical Lift Alt

Kevin:

The Load EE005855 with Mechanical Lift engines has been certified of the parts in the Kit.

Engine model : MLC3016 engine serial numbers: EE4045D123456, EE4045D123457, EE4045D123458 and EE4045D123459.

Attached you will find a picture of the parts included in the Kit.



MVC-040S.JPG

**Good news!** We found the problem with the collars that Mechanical Lift reported. We found in the reject area a container with collars different size than the actual, the parts arrived to MJD from the supplier mixed, the operator separated those and send the bigger to the reject area. Attached you will find the picture with the both collars:



COLLAR R94351  
PROBLEM..ppt

We will include the collar R94351 to the Receiving inspection program.

Please keep me informed about the Mechanical Lift feedback.  
 Regards.

**Carmen**

Assembly Quality Engineer  
 Phone/Fax (xxx) xxx-xxxx  
 e-mail: Maria@engine.com

-----Original Message-----

**From:** Maria  
**Sent:** Friday, May 04, 2001 7:25 AM  
**To:** Kevin; Dave  
**Cc:** Evangelina; Fernando; Jose Juan

**Subject:** RE: Mechanical Lift Alt

Kevin:

Please send me the collar wrong size and supply me a picture as you suggest, To understand better the problem, because we meassured the collars and are in specification and we do not use other similar part here in MJD.

For the washers do not worry we can find other way to send them.

By other hand We will continue checking the Mechanical Lift engines before ship to Mechanical

Lift until the problems disappear (collar and rust in turbo.)  
Regards.

**Carmen**

Assembly Quality Engineer  
Phone/Fax (xxx) xxx-xxxx  
e-mail: Maria@engine.com

-----Original Message-----

**From:** Kevin  
**Sent:** Thursday, May 03, 2001 5:03 PM  
**To:** Dave; Maria  
**Cc:** Evangelina; Fernando; Jose Juan  
**Subject:** RE: Mechanical Lift Alt

Carmen,

I have inspected the wrong collar. They have a least 50 collars that are the wrong size. I have one that I can send you and supply a picture for quicker reference next week.

At the widest part of the collar they will appear to be the same as the right collar. The problem is the taper at the bottom. It is very thick and much different than the correct part when held together.

I suggest that the narrowest part of the taper be checked. It appears that the collar has at least a 3 (?) mm wide edge instead of a nice taper.

**ALSO**, while we are talking about the alt parts. Currently the washers in the same kit are being sent all taped together flat and in single file. Removing the washers from the tape with gloves or with out gloves is **EXTREMELY** difficult to do in a timely manner. Can we please send the washers a different way.

Kevin

-----Original Message-----

**From:** Dave  
**Sent:** Thursday, May 03, 2001 11:03 AM  
**To:** Maria; Kevin  
**Cc:** Evangelina; Fernando; Jose Juan  
**Subject:** RE: Mechanical Lift Alt

Carmen,

The "**Wrong**" collar measures **50 mm** O.D. diameter.

The "**Correct**" collar measures **25 mm** O.D. diameter.

In the area where the RE504096 kits are assembled, is there a collar that is 50 mm O.D.?

Thanks for offering to visually inspect all of the Mechanical Lift engines prior leaving the engine factory.

**Dave**

Phone: (xxx) xxx-xxxx

xxxxxxxxxxDave@engine.com

-----Original Message-----

**From:** Maria  
**Sent:** Thursday, May 03, 2001 10:50 AM  
**To:** Kevin; Dave  
**Cc:** Evangelina; Fernando; Jose Juan

**Subject:** FW: Mechanical Lift Alt

Kevin/David:

One more question .

Could you verify which dimension is called "too large" ?

We measure the parts and the parts meet the specification according to the part print I sent.

We reviewed in the warehouse 370 parts visual and all looks like the print.

We will continue reviewing the Mechanical Lift engines before the engines leave of the plant.

Regards.

**Carmen**

Assembly Quality Engineer

Phone/Fax (xxx) xxx-xxxx

e-mail:Maria@engine.com

Dave:

Good afternoon.

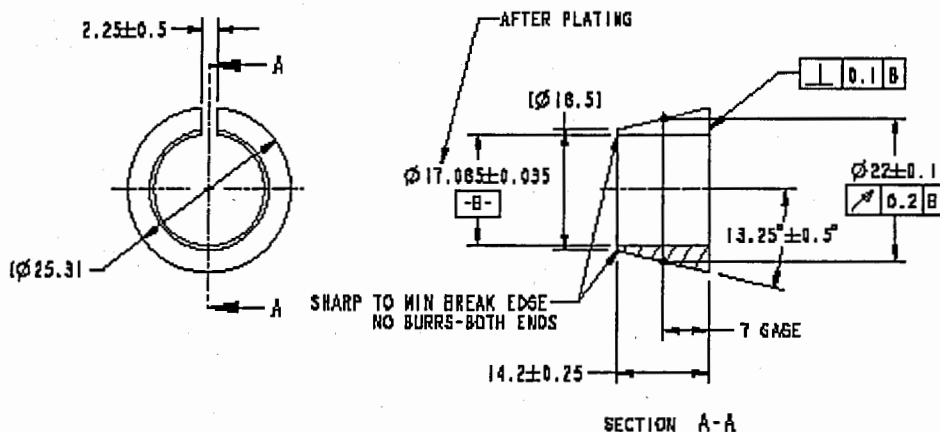
Only to clarify:

1) Are The part. numbers in the Mechanical Lift kits the same part. numbers that are in the BOM (specification).?

2) Do The parts arrived in the kit of the Mechanical Lift engines Aren't they the ones that Gradall needs?.

This is the drawing of the part number R94351 .

We will measure 10 parts(R94351) to print and verify if all the characteristics meet the specification .



**Carmen**



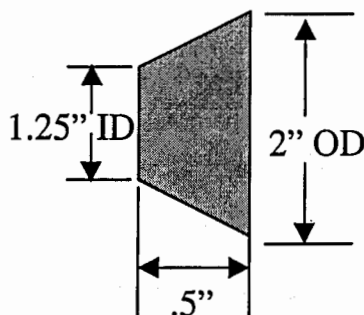
Assembly Quality Engineer  
 Phone/Fax (xxx) xxx-xxxx  
 e-mail: Maria@engine.com

-----Original Message-----

**From:** Dave  
**Sent:** Wednesday, May 02, 2001 1:01 PM  
**To:** Maria; Yuriko  
**Cc:** Kevin; Christopher; Al; Benny  
**Subject:** FW: Gradall Alt

## Carmen/Yurik,

Mechanical Lift states that some of the RE504096 kits are missing the R94351 collar or they have a collar that measures of 2" OD, 1.25" ID and .5" wide/deep. The drawing below is of a part, which Mechanical Lift is finding in the RE504096 kit.



<< OLE Object: Picture (Metafile) >> <<

OLE Object: Picture (Device Independent Bitmap) >>

The Quality Assurance people for Mechanical Lift have reported in consistence in the white bag contents. Dennis of Mechanical Lift stated that the following engine models have the inconsistency:

FBA00396-4 (9140-3030) PE4045DF150 engines

FBA00398-4 (9147-3016) PE4045DF150 engines

FBA00399-3 (9147-3017) PE4045TF150 engines

As listed in the Mechanical Lift kit, the correct parts for the Mechanical Lift engines (per Al) are the following:

R94350 pulley

R94351 collar



KIT GRADALL.doc

<< File: KIT Mechanical Lift.doc >>

I have requested serial numbers and as soon as we have this data we will forward the serial numbers to your attention. Mechanical Lift has requested a CAR due to the length of time it has taken to resolve this mix-up of parts.

Regards,

*Dave*

Phone: (xxx) xxx-xxxx

XxxxxxDave@engine.com

I'm changing the (2) 24M7055 washers with (1) AT154266 washer.

Al

-----Original Message-----

**From:** Dave  
**Sent:** Wednesday, May 02, 2001 1:04 PM  
**To:** Kevin  
**Cc:** Allan  
**Subject:** Mechanical Lift hardware

Kevin,

Carmen sent me a note to inform me of the contents of the RE504096 kit for Mechanical Lift. Kit consists of the following parts:

- 1 - R64525 washer
- 1 - 14M7296 nut
- 1 - 19M7812 bolt
- 1 - 19M7867 bolt
- 2 - AT154266 washer (changed from 24M7055 washer)
- 1 - R94350 pulley
- 1 - R94351 collar

*Dave*

Phone: (xxx) xxx-xxxx

Xxxxxxx Dave@engine.com

-----Original Message-----

**From:** Allan  
**Sent:** Tuesday, May 01, 2001 11:31 AM  
**To:** Dave  
**Subject:** FW: Mechanical Lift Alt

FYI

-----Original Message-----

**From:** Kevin  
**Sent:** Wednesday, January 10, 2001 10:39 AM  
**To:** Elsie; Al  
**Cc:** Maria; Jose; Evangelina; Samuel; Benny  
**Subject:** RE: Mechanical Lift Alt

Elsie,

Talked to Mechanical Lift and told them they will be getting two washers and not one. They do not have a problem with this.

I checked to see when the next shipment of engines to Mechanical Lift would be and it is next week Jan 16. I anticipate that the changes will be in effect with these and future engines sent to Mechanical Lift.

I have supplied Mechanical Lift with assemble instructions some time ago.



Gradall Alt.ppt

&lt;&lt; File: Mechanical Lift Alt.ppt &gt;&gt;

As far as warrant, this will need to be monitored closely.

Kevin

-----Original Message-----

**From:** Elsie  
**Sent:** Wednesday, January 10, 2001 9:52 AM  
**To:** Kevin  
**Cc:** Maria; Jose; Evangelina; Samuel; Benny  
**Subject:** RE: Mechanical Lift Alt

KEVIN:

The pulley and collar are on transit to MJD. We expect to receive these parts tomorrow. However, we can't get the washer AT154266 any time soon, but we can substitute it for two 24M7055.

	AT154266	24M7055
ID	8.4	8.4
OD	17	15
THICKNESS	3.2	1.6
TYPE	24H	24H
MATERIAL	STEEL	STEEL
FINISH	B	B

Would this be OK for Mechanical Lift?

We can adopt the change on the next batch of engines. Please confirm if you want us to proceed with the change.

Another question I have is, who is going to be responsible for sending work instructions to Mechanical Lift? We have to make sure they are assembling the parts correctly. For what Al said last Monday, our customer was placing the washer R64525 in a wrong position, and this could be the reason of failure. Are we going to accept warranty claims on this? Is it our responsibility that Mechanical Lift misplaced the washer?

Well, please let us know your opinion about this issue. We will gladly help in anything needed to resolve this.

Have a great day.

P.S. I still do not have a serial number break. I will be able to provide this information until we launch the engines.

**Elsie**

**Quality Engineer**

Phone/Fax (xx) xxx-xxxx

E-mail: Elsie@engine.com

-----Original Message-----

**From:** Kevin  
**Sent:** Tuesday, January 09, 2001 1:18 PM  
**To:** Elsie  
**Subject:** Mechanical Lift Alt

Elsie,

Do know at what serial number, of the engine, the two piece pulley will start at?

Thanks!

*N e v i*

*OEM Field Service*  
(xxx)xxx-xxxx

David:

In the file below, you will find the specification for the Mechanical Lift Kit.  
Please inform me if you need additional information.

Thanks.



KIT GRADALL.doc

**Carmen**

Assembly Quality Engineer  
Phone/Fax (xxx) xxx-xxxx  
e-mail: MariaC@engine.com

-----Original Message-----

**From:** Evangelina  
**Sent:** Wednesday, May 02, 2001 9:05 AM  
**To:** Maria  
**Subject:** SPEC for Mechanical Lift KIT

Carmen;

As you requested, attached you will find the SAP spec for the Alternator's Mechanical Lift KIT vs. the Work Instruction.

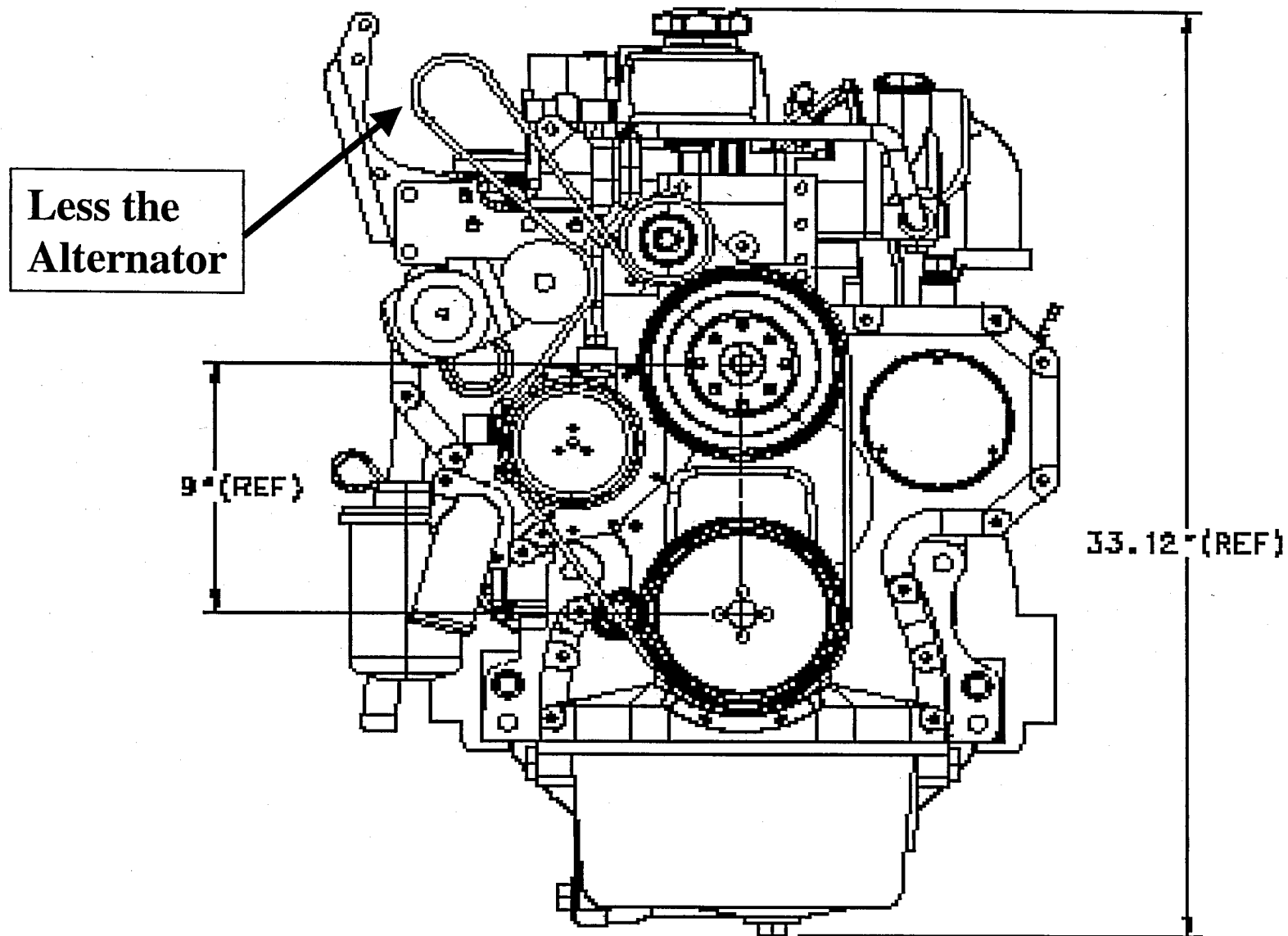
If you need something else, please let me know.

Regards.

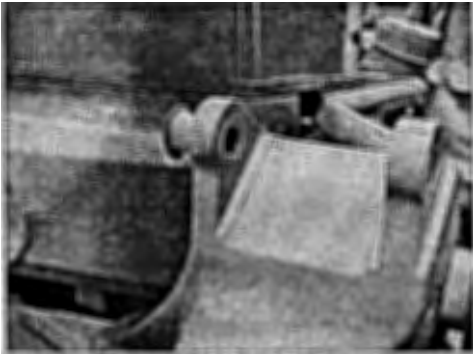
**Eva**

Assembly Process Engineer  
Tel. & Fax (xxx) xxx-xxxx  
E-mail: Evangelina@engine.com

# Front Display as Arriving from Diesel Engine Supplier

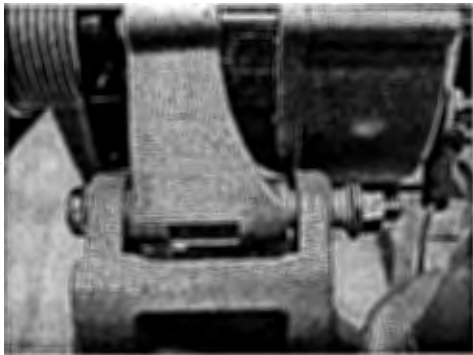


# ANSWERS



Question #3, Assembly person taps the bushing so it completely contacts the alternator housing?

The bushing is partially assembled before the final torque is given. We do not have an established limit to where the bushing must be introduced. The final position is given when the nut is torqued.



In these pictures you can see how the bushing was first assembled and how it ended up when the nut was torqued.

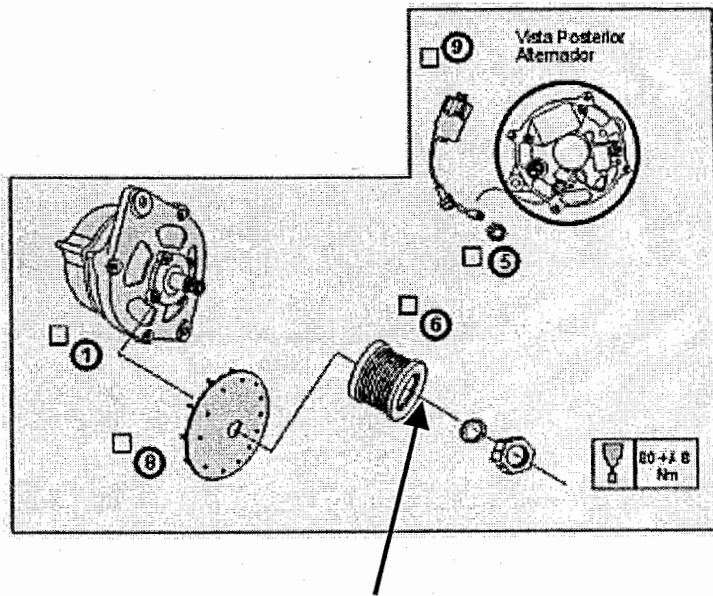
Question #4, At this point, if there is a big gap where the washer goes, do you loosen the bracket mounting bolts or any other steps for aligning parts?

We really do not experience this problem during assembly. We never loosen the bracket mounting bolts.

# ANSWERS

Question #1, Is there much tolerance (size of bolt hole) between the bolt hole and the bolts? Can the bracket move much on the bolts?

No, there is not much tolerance. However, we need the alternator spec to answer this correctly.



Needs R94351 collar

Question #2, What is the procedure for installing the fan, pulley and torque for the pulley?

The fan is placed on the alternator (blades facing to the housing). Then the pulley is placed over the fan. After this, the washer and nut are assembled and hand tightened. Finally, the nut is torqued with a pneumatic gun to 80+/-8 Nm.



This picture shows the engine with its bracket, just before the alternator is assembled. It is the starting point.

Question #1, Is there much tolerance (size of bolt hole) between the bolt hole and the bolts?

Can the bracket move much on the bolts?

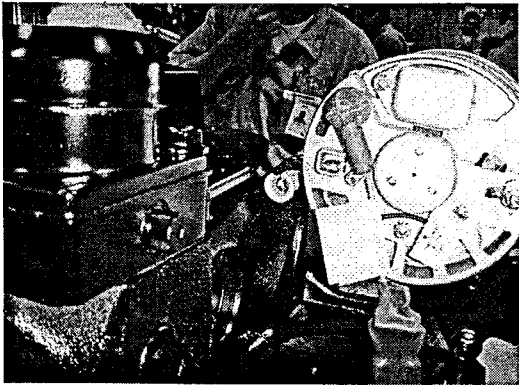


The alternator is placed on the bracket.  
Question #2, What is the procedure for installing the fan, pulley and torque for the pulley?



Then the bolt are installed manually on the right hand side bracket hole. The bolt is hand tightened.





Then, the bushing is manually assembled to the bolt and into bracket.



The bushing is completely introduced to the bolt by hitting it softly with a hard object (we use a socket).

Question #3, Assembly person taps the bushing so it completely contacts the alternator housing?



Then the bolt and washer are installed manually on the left hand side bracket hole. The washer goes between the bracket and the alternator. The bolt is hand tightened.

Question #4, At this point, if there is a big gap where the washer goes, do you loosen the bracket mounting bolts or any other steps for aligning parts?



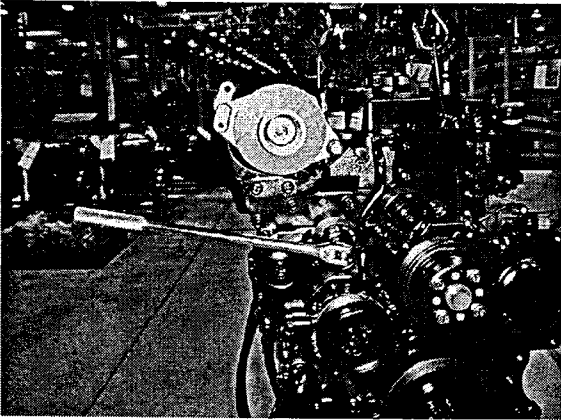
Install the nut on the back of the bushing.  
(hand tightened)



Hold the nut with a 15mm wrench and  
tighten the bolt with a pneumatic gun  
(35+/- 4Nm)



Torque the upper left bolt with a  
pneumatic gun to 35+/-4Nm.



The idler pulley is moved in order to install the belt. We use a 15mm socket and a breaking bar as a lever to push the pulley to the right.



The belt is placed, making sure that it is completely seated on all pulleys.

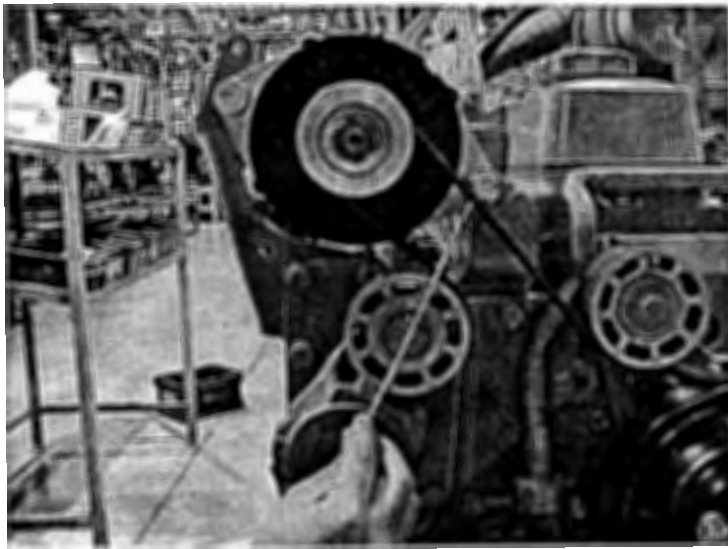
Question #5, Does the assembly line ever check to see if the pulleys are aligned?



Return the idler pulley to its original position. The belt will be automatically tightened.

# ANSWERS

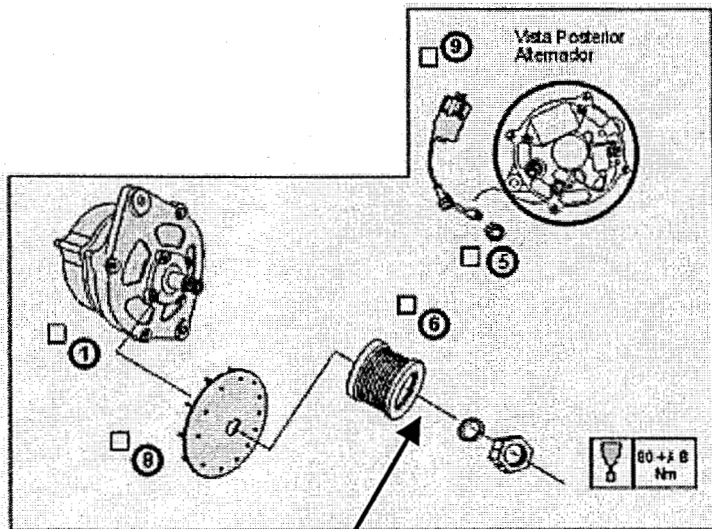
Question #5, Does the assembly line ever check to see if the pulleys are aligned?



The height of the fan and crank pulleys are verified with a height gauge. The distance between the centers is measured. Other than that, the only revision we make is verifying that the tensioner bolt is aligned with the alternator right hand side bolt (alignment shown in picture). This is not a formal check in our process. However, all the operators are aware of this quick check.

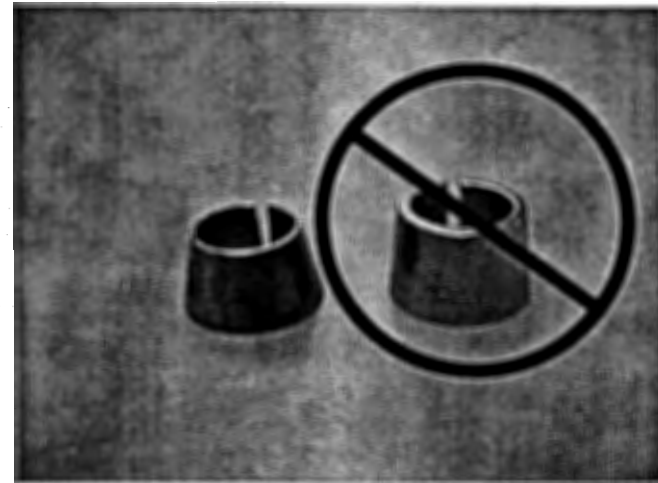
## Install the correct pulley to Mechanical Lift alternator

### Wrong Assembly



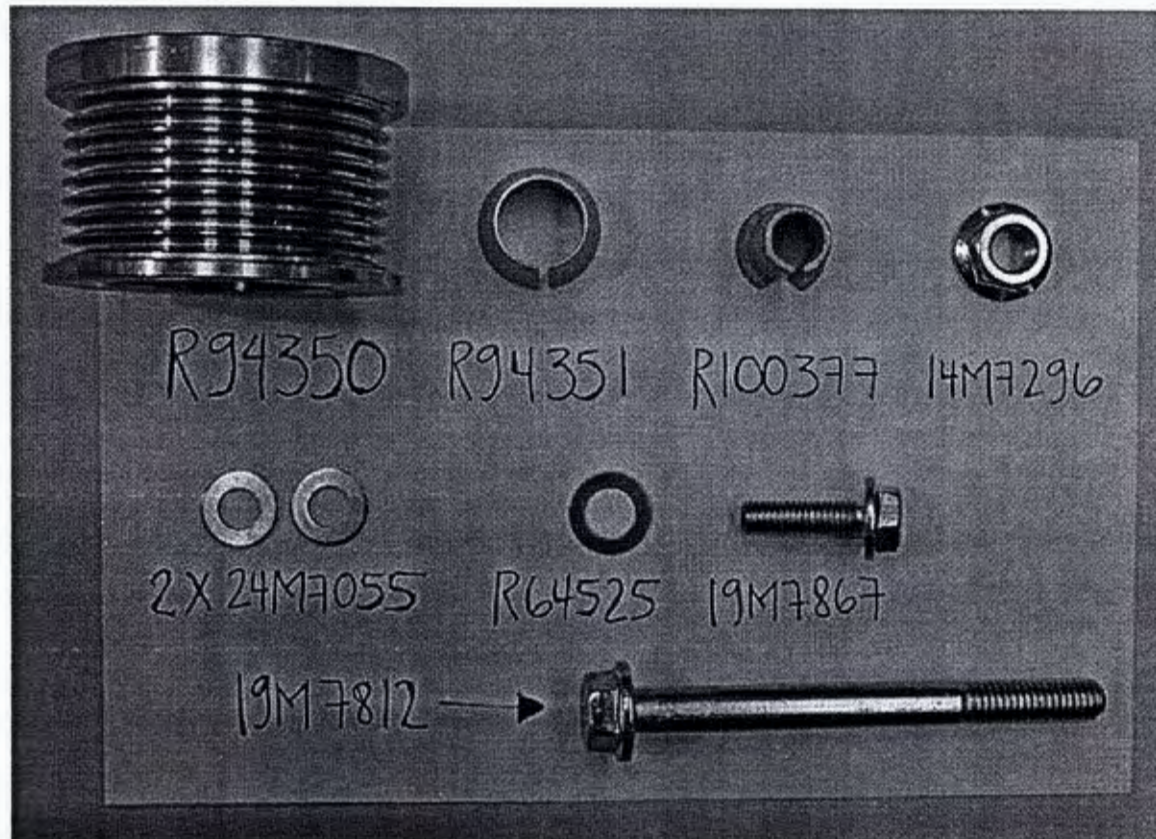
Missing Collar

### Correct Assembly



Insert a drawing of the correct assembly of alternator pulley, pull it from a parts manual.

Photo of the parts shipped from the Diesel Engine factory for each Mechanical Lift engine.



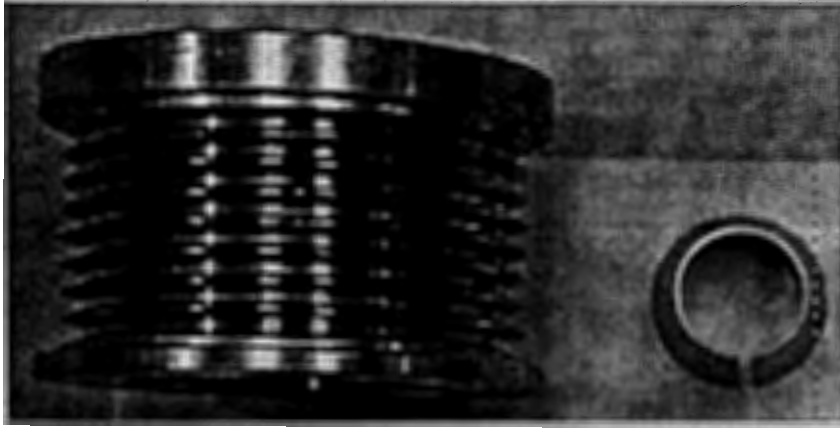


# List of parts in the hardware bag attached to every Mechanical Lift engine

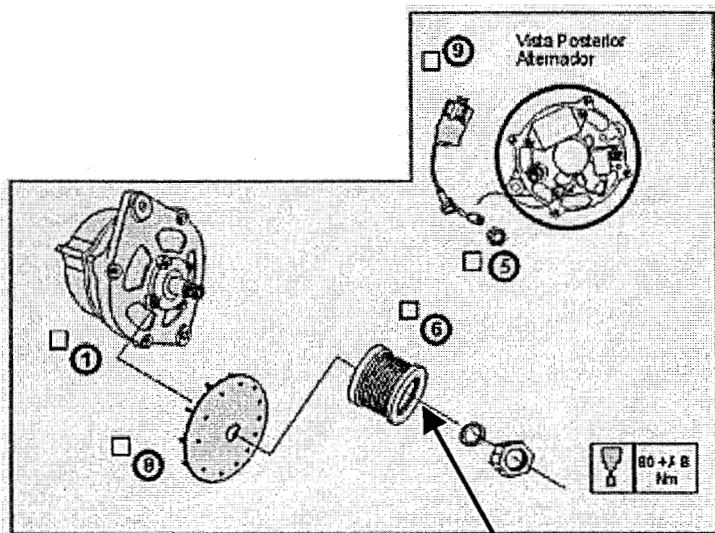
RE504096		KIT, ENGINE INSTALLATION	
PE00		Motores John Deere,S.A.de C.V.	
1			
Component	Quantity	Un	ICt
Component description		Asm	Slc
R64525	1	PC	L
WASHER, SPECIAL			
14M7296	1	PC	L
NUT, JDS14M HEX FLANGE			
19M7812	1	PC	L
SCREW, HEX FLANGE			
19M7867	1	PC	L
SCREW, HEX HEAD FLANGE			
24M7055	2	PC	L
WASHER			
R94350	1	PC	L
PULLEY, ALTERNATOR			
R94351	1	PC	L
COLLAR, ALTERNATOR PULLEY			

# Alternator Assembly Procedure For Mechanical Lift Equipment



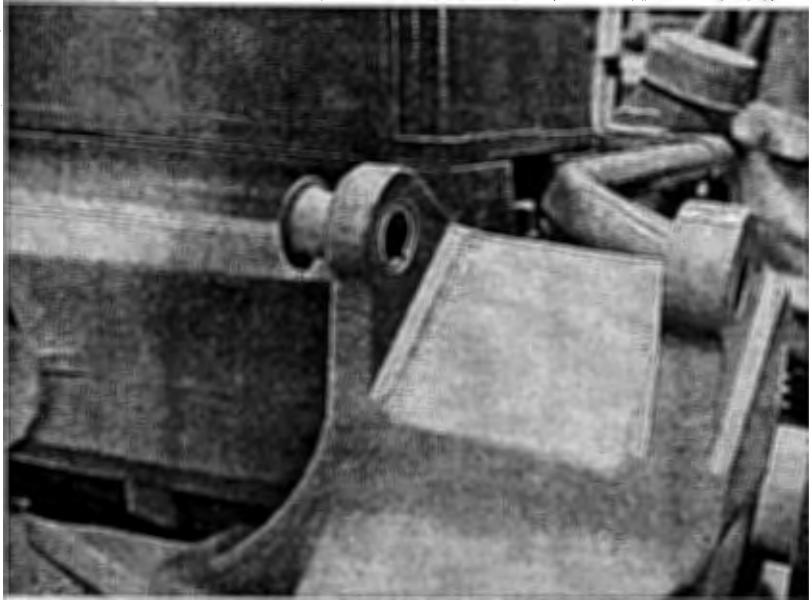


- Install R94350 Pulley and R94351 collar onto alternator shaft.



Location for R94351 collar

- Tighten alternator pulley retaining nut to 80 +/- 8 Nm.



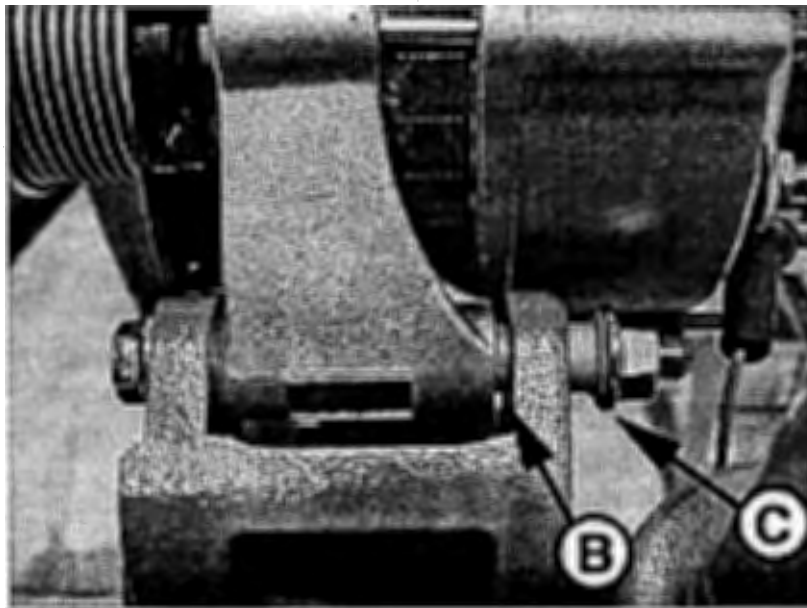
- Install R100377 bushing into alternator bracket.



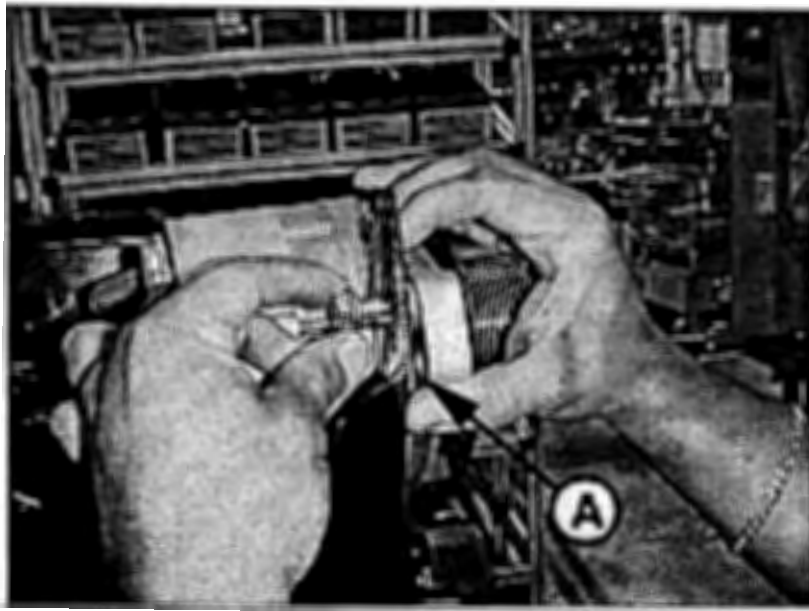
- Install 19M7812 bolt until slightly into alternator.



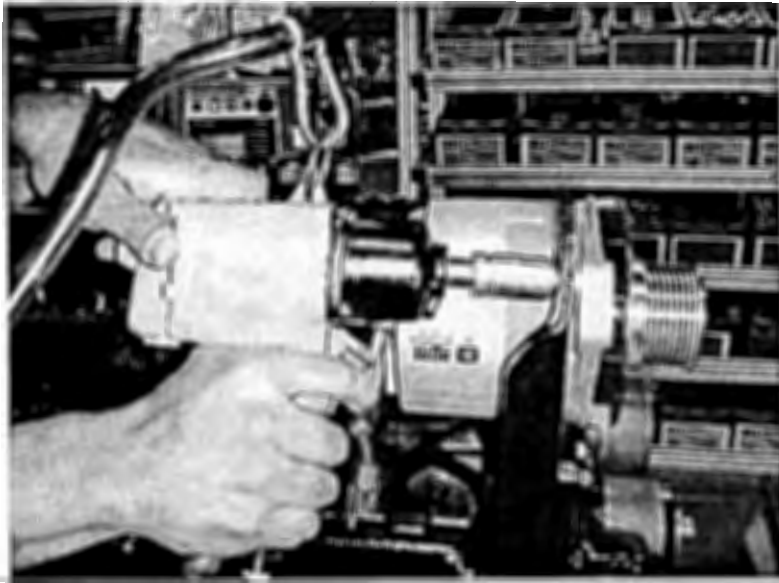
- 19M7812 bolt will hold alternator in bracket.
- Install R64525 washer at location “B”. The washer is .91mm thick.



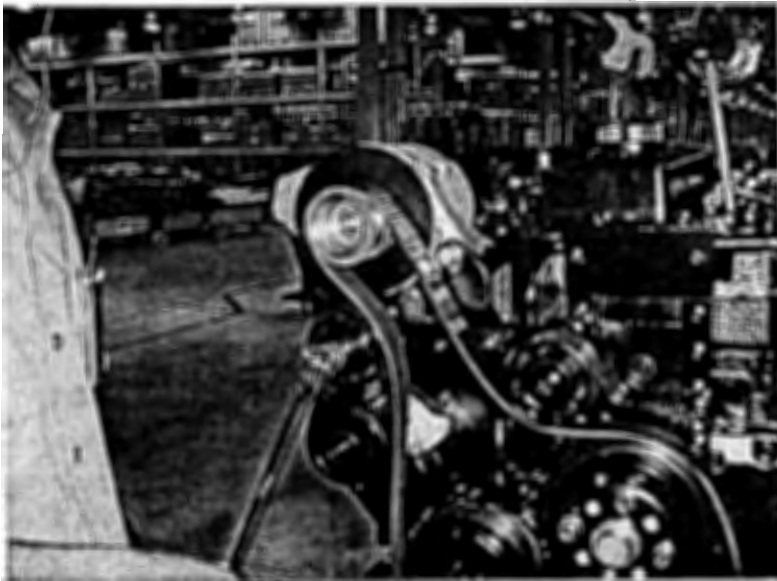
- Tap bushing “C” with hammer the to seat it against washer.
- Push the 19M7812 through bushing and install 14M7296 nut.

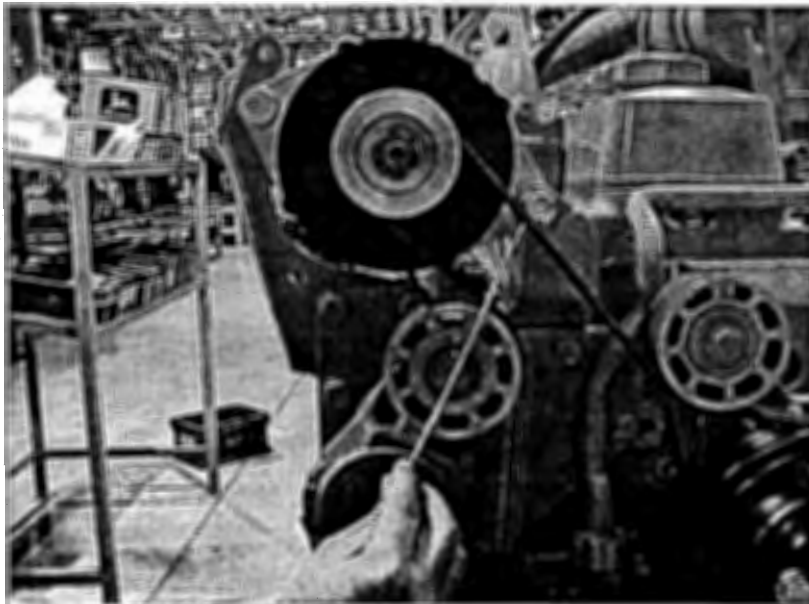
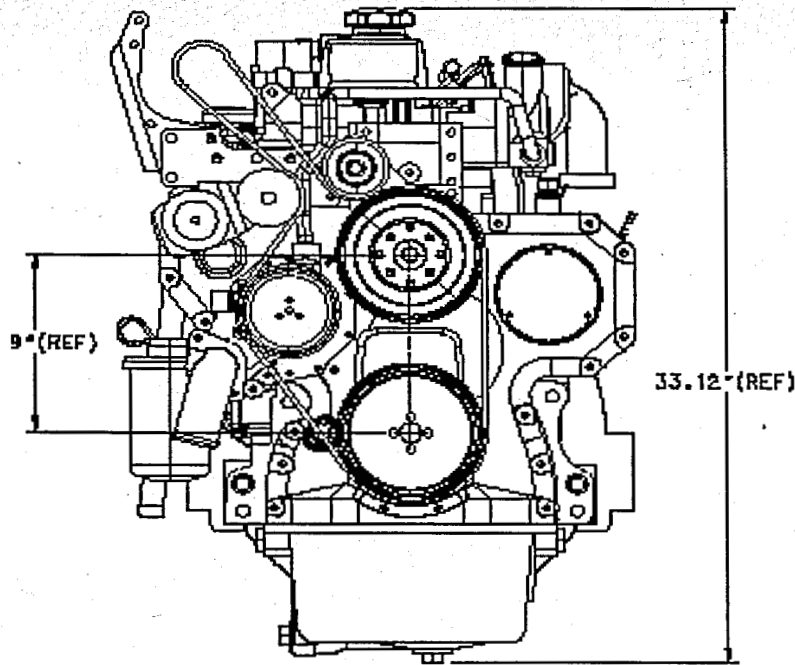


- Hold bolt in bracket and tighten nut.
- Tighten nut to (35 +/- 4 Nm)
- Install AT154266 washer between top strap & behind Alt. (refer to key "A").
- The washer is 3.2 mm thick.
- Bolt installed through strap, washer and into the alternator.



- Tighten bolt (35 +/- 4 Nm).
- Hold fan belt tension arm away from belt with a 1/2" drive tool.
- Install the fan drive belt onto the pulleys.





- Install fan drive belt around the pulleys as shown in illustration.
- Check position of tension are for proper fan belt tension, arm should be in the 1 o'clock position.